January 1960

Bell Laboratories

RECORD

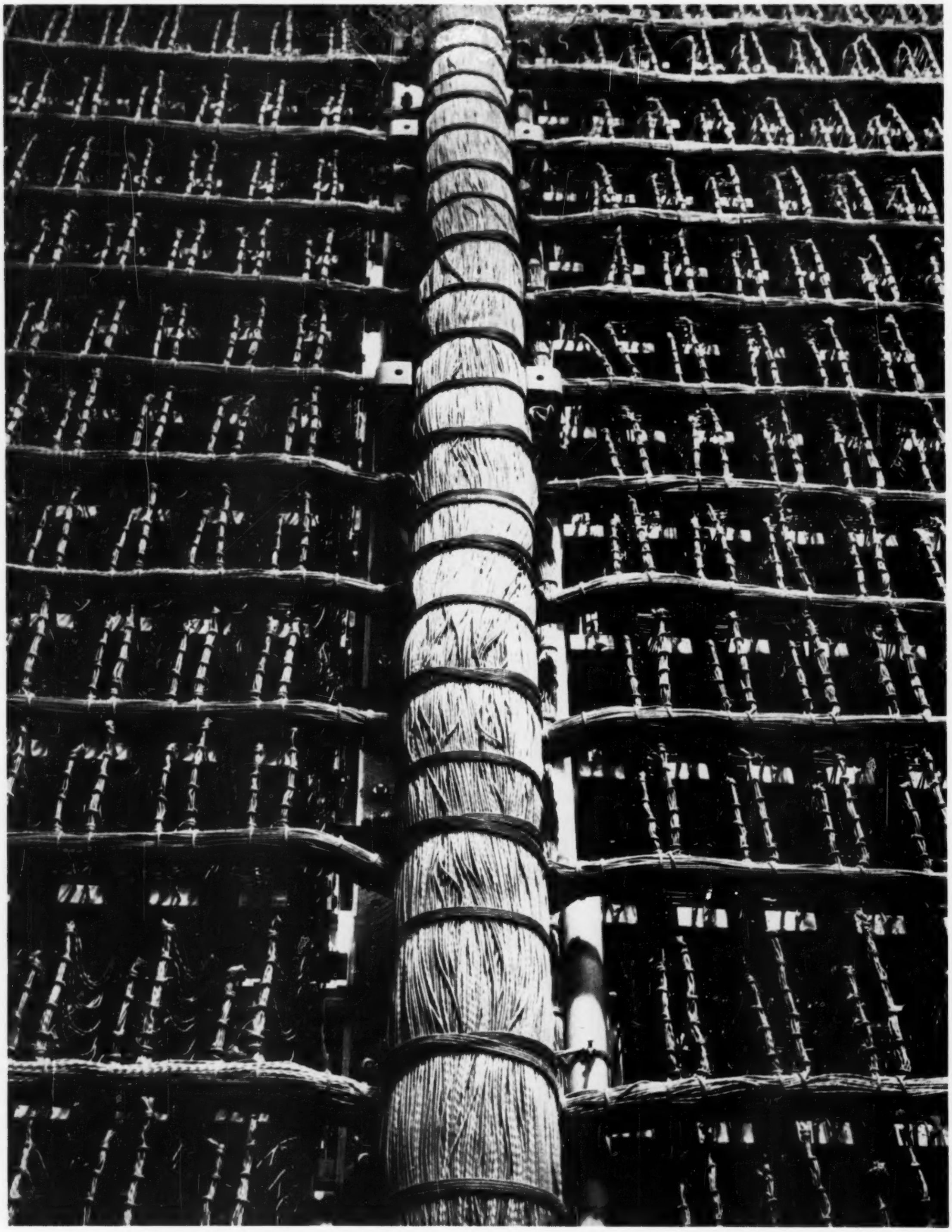
THE BELL LABORATORIES RECORD is published monthly by Bell Telephone Laboratories, Incorporated, 463 West Street, New York 14, N. Y., J. B. FISK, President; K. PRINCE, Secretary; and T. J. MONTIGEL, Treasurer. Subscription: $2.00 per year; Foreign, $2.60 per year. Checks should be made payable to Bell Laboratories Record and addressed to the Circulation Manager. Printed in U. S. A.

Bell Laboratories **RECORD**

Volume 38 • Number 1 • January 1960

Contents

Cover *Two pen recorders moving across a plotting board simulate an engagement between a Nike missile and its target. W. A. Glaser, left, and L. A. Williams follow the action. Simulation of this kind, on the Nike Systems Tester, plays an important part in developing Nike missile system components* *(see p. 26)**.*



Wired memory. This intricate pattern of wires interconnects the many relays that perform the complex memory and logic functions required of the "marker" in directing calls through No. 5 crossbar.

In telephone switching, "memory" is as old as the very first telephone call for which an operator had to remember the called number. But modern automatic switching systems, and those of the future, use the idea of memory in ever more subtle ways to provide efficient, economical service.

R. E. Hersey

MACHINE MEMORY
In Telephone Switching

The concept of "memory" is difficult to define concisely. Webster's Dictionary calls it "the power or function of reproducing and identifying what has been learned or experienced." A person with an excellent memory is regarded with envy — he seems to be able to store in his mind a very large number of facts and to keep them neatly ordered on file for future use. Too often, however, we tend to emphasize this "storage and filing" aspect of memory and overlook the need to recognize or recall.

It is not enough to store a fact; we must also be able to locate it, pull it out of its pigeonhole, and interpret its meaning. A photograph has stored information, but it may represent no real memory except to the person who has experienced the scene. If we see notches that have been cut into the stock of a hunter's rifle, the information is meaningless until we know whether the notches represent hits or misses. Thus, as we here use the term "memory" in connection with telephone switching systems, the functions of reconstructing and identifying stored information are always implied, even though the specific methods of performing these functions are treated briefly.

Every telephone switching system employs some sort of stored information. If it is reused and interpreted, it represents memory. In a manual office, an operator temporarily remembers her instructions for a particular call: to interconnect two switchboard jacks with a pair of cords. She then promptly forgets, but the information persists since it is marked by the association of the cords with jacks on the switchboard. When the cords are pulled down, the record is irretrievably lost.

Before pulling them down, however, the operator may have acted upon the stored information and transferred the jack numbers to a new type of memory — a "ticket." These jack numbers may not be the customers' telephone directory numbers. If not, they must be translated, which employs a third form of memory. Additional memory is also involved in determining the charge, summarizing the bill, and addressing the envelope.

In the step-by-step switching system, electromechanical switches connect two terminals together under direct control of the customer's dial — an action analogous to the operator's use of plugs and jacks. Stored information exists in the switches, but there is no method for recalling or recognizing the switch locations.

Panel and crossbar switching systems, and the electronic switching system being developed, are each more sophisticated than its predecessor and each relies more and more on devices seemingly approaching human memory in order to achieve faster and more complicated switching feats.

Memory in the Panel System

Memory in the earliest panel system employed rotary switches. Each customer was first connected to a storage circuit, called a sender, into which he dialed his wanted number. In the sender, each digit he dialed was stored or remembered temporarily by the rotation of a switch one step for each pulse of the dial. This is much like the step-by-step switch locations, or like the operator temporarily remembering the verbal numbers. However, in the panel system this stored information is not only recognized, but is acted upon by a translator which contains what is called "wired logic." Each different setting of rotary switches finds certain wired paths through the translator for operating relays. These relays lock in the operated state and again remember the wired translation. Thus, they direct the panel selectors to particular locations that are quite independent of the decimal instruction originally received. The wires of the wired logic can be unsoldered and reconnected to get different routings as desired.

Later vintages of panel and crossbar systems use relay memory instead of rotary-switch memory. In these cases, relays are grouped in the familiar counting arrangement to count the dial pulses as they arrive. During the interval between digits, the decimal value of the dialed digit is transferred to another group of relays.

Such a group might be ten relays, each remembering its assigned decimal value. To conserve apparatus, however, smaller groups are customarily used and are operated in combinations — one might say that the memory language has been changed or reduced to shorthand.

Some of the combinations in use are shown in the table on this page. It will be seen that most such combinational codings are chosen so that the elements are additive in order to aid those versed only in the decimal system. The decision regarding which code to employ usually is based on cost. The arrangement shown in the first column obviously requires ten elements. If they are just marks on paper or switch positions, they

	1	2	3	4	5	6	7
Code→	**One Out of Ten**	**One, Two, or Three Out of Four**			**One or Two Out of Six**	**Two Out of Seven**	**Two Out of Five**
Decimal Digit ↓	**1 to 10**	**1-2-4-5**	**1-2-4-6**	**1-2-4-8**	**1-2-3-4-5-6**	**0-1-2-3-4-5-00**	**0-1-2-4-7**
1	1	1	1	1	1	00 + 1	0 + 1
2	2	2	2	2	2	00 + 2	0 + 2
3	3	1 + 2	1 + 2	1 + 2	3	00 + 3	1 + 2
4	4	4	4	4	4	00 + 4	0 + 4
5	5	5	1 + 4	1 + 4	5	5 + 0	1 + 4
6	6	1 + 5	6	2 + 4	5 + 6	5 + 1	2 + 4
7	7	2 + 5	1 + 6	1 + 2 + 4	1 + 6	5 + 2	0 + 7
8	8	1 + 2 + 5	2 + 6	8	2 + 6	5 + 3	1 + 7
9	9	4 + 5	1 + 2 + 6	1 + 8	3 + 6	5 + 4	2 + 7
0	0	1 + 4*	4 + 6*	2 + 8*	4 + 6*	00 + 0	4 + 7

Column 1: Self-checking in that one and only one element is used.

Columns 2-5: Self-checking not easily arranged.

Columns 6 and 7: Self-checking in that two and only two elements are used.

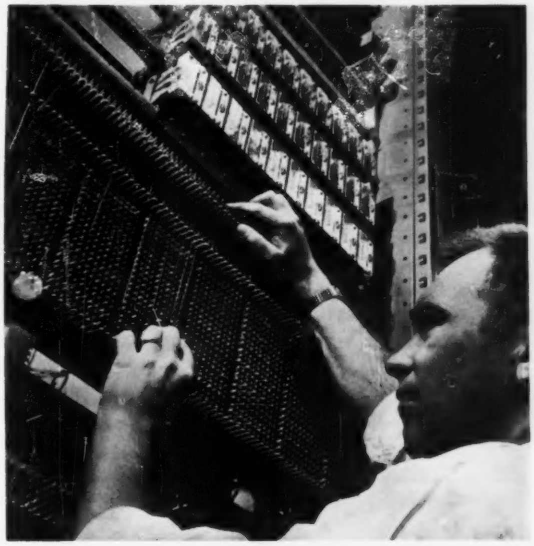
*Can use blank combination for 0—that is, no elements used.

can be quite inexpensive. But if each is a relay, the basic cost goes up.

In the design of memories, the trend has been away from motor-driven devices. Rotary switches are in this category. The rotary switch has to pass other terminals in arriving at its memory point. In addition, it has to be further rotated to return to normal. Both of these actions consume valuable time. Therefore, memory recording has moved toward simpler two-state devices: relays — operated or not operated — magnetic spots on tapes or on the periphery of rotating drums, magnetic states within ferrite cores or sheets, magnetic stresses in wires called twistors, electrostatic charges on capacitors or on certain crystalline materials, electronic charges on the face of electron beam tubes, opaque or clear spots on photographic plates which can be read by directing the light produced by an electron beam through lens arrays, to name a few.

Relays, while an order of magnitude faster than rotary switches, are again an order slower than electronic devices. But they have many advantages. They will carry quite a load of both "make and break" and sequence contacts, and these can be arranged with other relays in "wired logic" patterns to give many direct answers without further processing.

To keep the number of relays (cost) to a minimum, we may use other forms of coding shown in the table. In columns 2, 3, and 4, for example, only four relays need be used to store any one of ten values. This may sacrifice some ability of the circuits to self-check for accuracy, but even here, the clever circuit designer may devise methods of error-checking. For instance, in the panel decoder and No. 1 crossbar marker, the 1-2-4-5 scheme (column 2) is used, and, for error-checking, all four relays are checked operated, and then the unwanted ones are released.



W. R. Rupp checks the cross connections on a translator circuit used in the No. 5 Crossbar system. Cross-connected wiring of this kind is very important in many types of machine memory.

The More Elegant Memory Codes

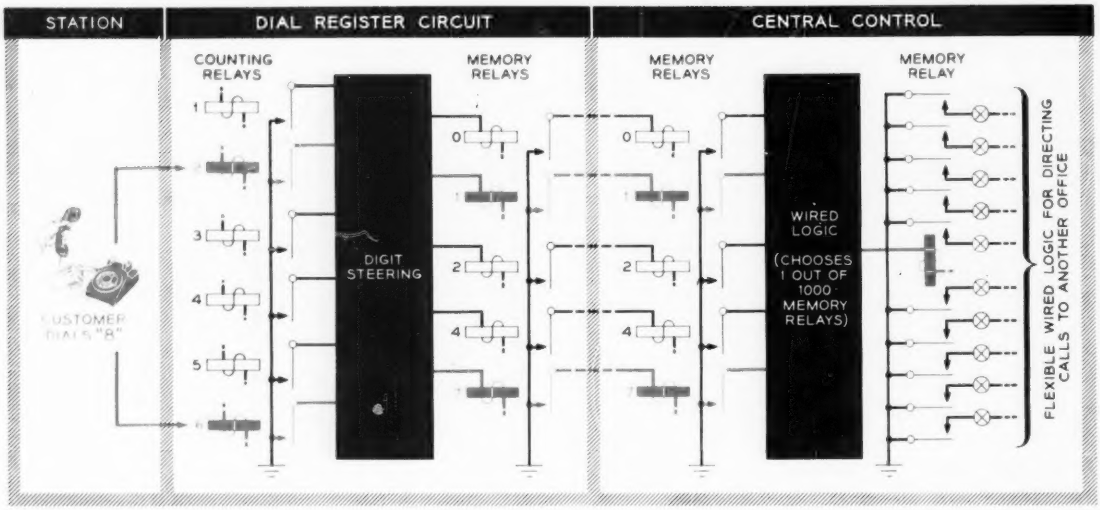
The codes shown in the last two columns of the table require more relays, but they are capable of self-checking by arranging part of their springs in wired logic to directly give one "answer," which indicates that two and only two relays are operated. The machine then knows that the other answers are correct, except in the case of dirty contacts or open leads. But here again, a good designer arranges the program so that a "no answer" will stop the call.

Thus, although information starts out as numerical in character, it really represents requests or commands which have been abbreviated. Dialing zero means, "I want an operator." Dialing 936-1212 means, "I want a report on the weather." Dialing 243-1234 means, "I want to talk to John Jones." Within the realm of logic programs for automatic switching systems or other machines, many requests and answers are in numerical form. Such machines ask many, many questions, and each question gets a yes or no answer. In relay logic, multiple answers can be obtained.

As the hardware or tools for building telephone systems become more economical and faster acting, their organization becomes more flexible and centralized. Units of the circuit become specialized — they do just one particular job but do it over and over again. Thus, digital information is rapidly tossed from one unit to another, each receiving, remembering, recognizing, translating, and giving another answer to another part of the circuit. The information is not always but frequently in numerical form, where it is again remembered and acted upon, and so forth.

Due to its "specialized" areas of memory and its "central control," the No. 5 crossbar system, latest member of the Bell System switching team, is the most versatile. It makes extensive use of two-out-of-five (2/5) coding, the last column of the table. The chief advantages of this code lie in its self-checking and additive elements.

In No. 5 crossbar, the digits dialed by the customer are first counted and temporarily remembered on the "five-and-above-five" (1-2-3-4-



Simplified representation of two of many forms of memory in No. 5 crossbar: digit "8" dialed by customer is first stored in the group of six relays (left), later is transferred to relays that use the two-out-of-five numbering code. Wired logic then finds a single relay for directing calls.

5-6) method (column 5). This is shown in simplified form in the circuit diagram on this page. In this diagram, the digits are applied first to the group of six relays at the left. The example used is the digit "8." From this group of relays, the digit is then transferred to a digit register with the 2/5 arrangement (first of the two registers in the center of the diagram). In the wire-spring relay model, this register consists of a simple package of five reed relays. Memory of the calling customer's line equipment, like the "jack" for the manual operator, is similarly remembered, but is not shown in this diagram.

After the first three digits (office code) are dialed, they are held, but their value is passed to a "pretranslator" circuit. Here they are again temporarily stored and acted upon by wired logic to determine how many digits the customer should dial. The answer is passed back and remembered in the register circuit.

In this same diagram, when dialing is complete the whole quota of digits is passed directly in 2/5 form to the "central control" indicated at the right. Here, the first three digits go through another transformation to arrive at a one-out-of-1000 "wired logic" relay whose contacts include many information bits — bits describing, for example, whether the call is for another customer in the same office, or for a customer in a nearby office, or whether it is a DDD call to some remote place. Again, this wired logic can be changed at will by changing wires.

If the call is local, the four digits following the office code are passed by central control into translators called "number groups," each handling 1000 numbers, where again wired memory elements translate and send back a number representing the "jack" location for the called line. Then, the equivalent of the "two-cord" connection is made for these two lines. Actually, however, the connection is established through crossbar switches controlled on an orderly numerical basis by central control.

If the call is going out of the office, other specialized circuits are contacted by central control, and into one of these circuits all of the digits of both the calling and called customers' numbers are passed and remembered in order to control outpulsing to the distant office. Finally, all are remembered by punching holes in paper tape — again in the 2/5 pattern — for billing purposes.

These are only a few of the many memory functions of No. 5 crossbar. Its great repertoire includes handling the switching of local calls, cooperating with all other local-type telephone exchanges, extending calls through tandem and toll offices, and serving as combined PBX and local offices.

No. 5 crossbar was the first switching system to have memory organization and central control flexible enough to handle DDD calls. Today, it is able to reach about 70 per cent of the more than 66,000,000 telephones in this country that have been brought into the nation-wide dialing plan.

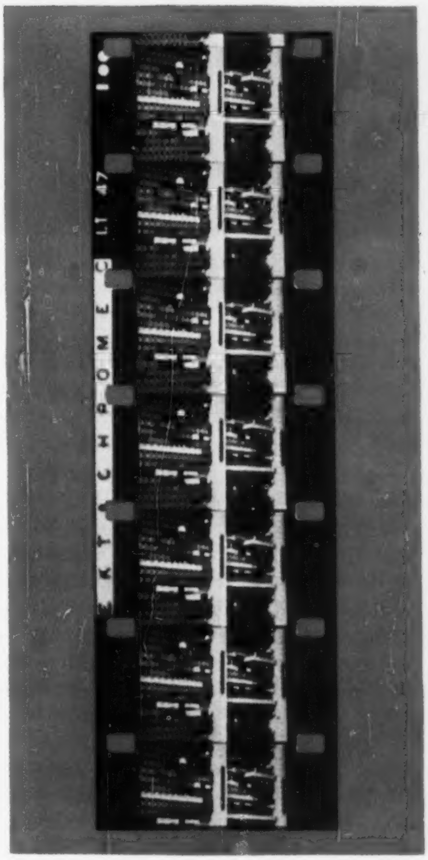
As mentioned earlier, most memory devices have just two states. In some, the two states are physical — that is, they can be sensed by one or more of our bodily senses. You can see that a relay has operated or has not operated, or you might feel it. A pencil mark on a paper or a string tied around your finger is either there or not there. In the case of the rotary switch, it has a number of positions. Even this can be thought of as being on or not on the first terminal, on or not on the second terminal, and so forth, until you learn that it is on, say, the seventh terminal.

In other devices, the two states are "physical" in another sense — scientific rather than bodily. The device passes current or it does not; it has a voltage charge or it does not; it is magnetized or it is not. Some of these can have multistates — positive voltage, no voltage, or negative voltage; North Pole magnetization, South Pole magnetization, or none. Or they may have more than three gradients of such states. Memory information might be assigned to each state and, moreover, the activation of each state requires only an extremely short time.

In general, it is desirable to use just two indications, and preferably both should be unambiguous in order to make the memory self-checking. For instance, a pencil mark on a paper, or no mark, would be more unmistakable if two kinds of marks were used, such as + or —, 1 or 0, red or green. Or in electronic devices, for example, a positive charge or a negative charge can

"Memory Devices": A New Laboratories Film

Telephone switching systems were certainly among the original users of machine memory. And Bell Laboratories engineers have long played an important role in the invention and use of memory devices. Some of the oldest and the newest memory units developed at the Laboratories have formed the basis for a new film, "Memory Devices."

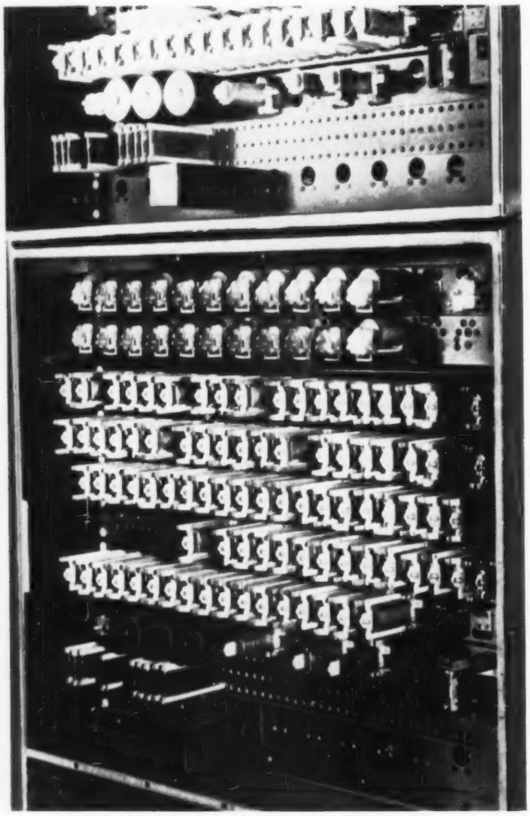


"Memory Devices," a 16-mm sound motion picture in color, has recently been produced by Bell Laboratories. This film shows many of the information-storage devices used in telephone switching and in modern computing-machine memories and explains how binary information is stored in them.

The film explains basic machine-memory concepts and terms, and describes examples of mechanical, electro-mechanical, magnetic, electrostatic and photographic memories in use or under development at the Laboratories. Specifically, it shows these memory devices: punched cards, punched tapes, relays, magnetic tape, magnetic drums, ferrite cores, ferrite sheets, twistors, capacitor arrays, the barrier-grid storage tube, and the flying-spot store.

R. E. Hersey was the technical consultant for "Memory Devices."

The film, written and produced by the Educational Film Production Group of the Publication Department, is designed for classroom use in college science and engineering courses. It will be distributed by the Operating Telephone Companies.



Machine memory, vintage 1925. In early panel systems, these three-digit senders temporarily stored customers' numbers. These numbers were coded and stored on groups of relays just as they are today.

be used. Thus, one knows that absence of indication was really not a lost positive indication.

The usual method of writing large combinations of these bits is as extension of that shown in column 4 of the table. It is called the binary code. Note that the four digit-values in column 4 are labeled 1, 2, 4 and 8 — each successive position is double the previous value. Extended, the values would read 1, 2, 4, 8, 16, 32, 64, and so on.

But these are *values* of the *position* of a digit, not the digit itself. The actual digit is either a 1 or a 0 — a yes or no answer to the question, "Shall we include the value of this *position* in adding up the decimal version of the total?"

Consider, for example, a binary number having seven digits. If it is written with ascending values from right to left, we have:

POSITION VALUE:	64	32	16	8	4	2	1
BINARY NUMBER:	0	1	0	1	0	0	1

The "answers" here are "yes" for the positions representing 1, 8, and 32, so the binary number means 1 + 8 + 32, or 41 in its more familiar decimal form.

The very high speed capability of some of the newer memory devices is being exploited in the design of the Electronic Switching System (RECORD, *October*, 1958). Here, more and more logic is being concentrated in masses of memory cells where questions and answers, or orders and responses, can be woven into myriads of program bits. This is done not by wires but by invisible threads of electronic impulses which record yes or no indications in each cell. Any day-to-day or year-to-year change of program to suit existing conditions can be executed in minutes, not by the slow method of unsoldering and resoldering wires, but by a simple control such as a typewriter keyboard or centrally prepared magnetic tape.

The already phenomenal dexterity of the great Bell switching team can be gleaned from the 1958 issue of the World's Telephones, issued by the American Telephone and Telegraph Company. It indicates that there were 63,620,900 telephones in the United States as of January 1, 1958, any two of which can be interconnected. This was a 5.7 per cent increase over 1957. At this rate, the telephones will double by about 1970 and double again well ahead of the year 2000. It also indicates that almost 76 billion local conversations took place in the United States during the year 1957. Since there are about 15 per cent unsuccessful attempts, this figure increases to over 87 billion dialing attempts, or an average of 10 million every hour, day and night. This does not include almost three billion long distance calls.

The United Nations estimates that the world population is presently growing by 5,400 every hour, or 47,000,000 a year. A number larger than the total population of France was added during 1958 to the people living on this earth, and this number will increase faster each year because death rates are decreasing more than birth rates.

According to the Statistical Abstract of the United States Census, the 1950 population of the United States will about double by the turn of the century if the present growth rate continues.

It needs no further emphasis that ordinary telephone service for all of these people will require adequate universal numbering plans for the United States, if not the world, and will require even faster and more flexible organization of machine memory. To meet this need, Bell Laboratories scientists and engineers are developing new and faster memory devices that are being adapted to the future needs of the great Bell machine.

The Bell System is helping to perfect three forms of educational TV sent over special closed-circuit facilities. This threesome includes grade and high schools, colleges, and government or industrial educational units.

C. A. Collins

Closed-Circuit Educational TV Systems

A short time ago, the noted physicist Edward Teller said he would like to see science become as popular as baseball. Maybe Dr. Teller's wish will be partially realized if scientific topics and science classroom courses continue to enjoy their yearly increase in TV presentation. As a visual medium, television seems to invest many of its subjects with a certain aura of popularity and relevance. Certainly the average youngster watching television develops a concentration he seldom exhibits in many of the other activities he is called upon to perform. The rapidly growing field of educational TV takes advantage of these home-grown viewing habits, and in addition provides a "you-are-there," close-up view of important demonstrations and experiments, which can be used to enhance the educational program.

Educational TV broadcast from a station can reach a large audience. However, the number of channels devoted to it simultaneously in a given area is limited by the available frequency allocations. This has given rise to the use of closed-circuit TV systems in which six or more channels may be transmitted simultaneously. Since the program material does not radiate into the atmosphere, transmission frequencies are not related to FCC allocations and may therefore be chosen to be advantageous from a transmission point of view. The availability of many channels has the advantage — for a school system — that a number of classes may receive TV instruction simultaneously. An additional advantage is that the programs can be directed only to those classrooms entitled to receive them.

Educational TV systems using coaxial cable have tended to fall into three general categories: local school systems serving grade and high schools, college systems serving a number of buildings on a college campus, and government (or industrial) training systems. The last may be used for general monitoring or supervisory purposes as well as for training.

At present, the largest local, closed-circuit system used in schools covers Washington County,

Maryland. All its educational TV programs originate at studios or schools in Hagerstown. This system serves about 16,500 pupils in 37 elementary classes and in junior high and senior high schools. It has six simultaneous channels operated over about 100 miles of cable. These channels are used for teaching science, music, mathematics, history and English. The project was originally subsidized largely by the Ford Foundation's Fund for the Advancement of Education, the Electronic Industries Association and the Chesapeake and Potomac Telephone Company of Maryland. Bell Laboratories has also played an important part in improving such closed-circuit systems, especially in planning and testing transmission equipment.

The second kind of system is typified by that at San Jose Teachers College in California. This system connects the campus buildings for general teaching purposes, and is used for practice teaching in buildings of the local school system. With this arrangement, practice teaching can be carried on in the local schools under the surveillance of unobtrusively located classroom cameras. The work of the young teacher can then be observed and commented on by professors and students.

A third kind of system is that at Redstone Arsenal, Alabama, which uses closed-circuit techniques to observe operating and maintenance procedures at missile-launching areas. This installation (in which the Army is the "user") is typical of a closed-circuit system used for other than strictly training purposes in that it allows observation by key personnel of dangerous procedures. Such a system also has wide application in business and military fields for training use, for quick reference to fast-changing price or seat-reservation information, and for many kinds of general supervisory use.

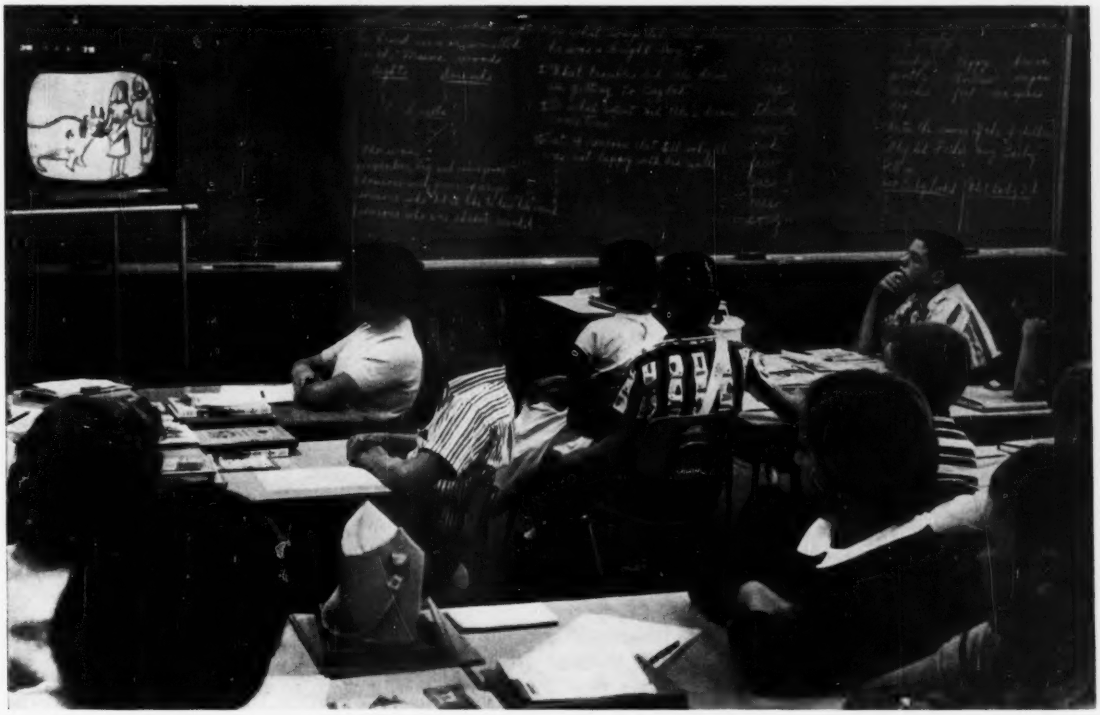
For these purposes, an originating point in a closed-circuit system requires camera tubes — either of the vidicon (less sensitive) or image-orthicon (very sensitive) type — to produce video signals. With these are associated monitor and control equipment used by program directors to present the material in the most effective sequence. In general, it is the function of the user (for example, the Hagerstown school system) to furnish this equipment, together with whatever lights and microphones may be required. The user then furnishes video and audio signals to the closed-circuit system at a level suitable for the various transmission components included in it.

Where there is only one transmitting site, the closed-circuit system needs transmitters for modulating video and sound signals to chosen channel frequencies at only one point. Where multiple transmitting, or "pickup" points, are needed, however, the closed-circuit system design becomes more complex, especially if each transmitting point must operate at any one of the channel frequencies used in the system. This raises the problem of reaching a number of receiving points from many transmitting sources over what is essentially a one-way system.

Several arrangements have been devised to serve this condition. One is "round-robin" construction. Here, the transmitted signals, no matter where originated, travel entirely around the one-way system, reaching all receiving points. Switching facilities, however, must effectively "open" the round robin "behind" each transmitting point. This is done by inserting a band-elimination filter to reject the particular channel band being transmitted — thus avoiding closing the round robin on itself, which might set up a "singing" condition. A block schematic of the round-robin circuit appears on page 12.

The round-robin principle is used at Hagerstown, but the system at Redstone Arsenal uses two completely separate systems, one for transmitting and one for receiving. There are a number of remote transmitting points. Any one of several vans — containing camera, control and

Closed-circuit TV finds various uses at the Army Ballistic Missile Agency, Redstone Arsenal, Ala.



Children in Hagerstown, Md., school watching a typical closed-circuit educational TV program.

transmitting equipment — can transmit from any one of these points. At a central control point, any program may be fed into the receiving system for training purposes on the Arsenal grounds, or the program may be connected to intercity transmission facilities for use at other training centers.

A closed-circuit system (similar to that described in this article) furnished by an Operating Telephone Company includes sufficient modulators to transmit the video and audio signals on as many as six channels at frequencies in the range from 25 mc to 100 mc. Because of its low cost and superior transmission characteristics, the Operating Companies use a Western Electric air-dielectric coaxial cable (coded the CA-1878) with a polyethylene jacket. Internally, this cable has the same 0.375-inch coaxial structure now employed in the L carrier systems. This cable may be mounted aerially on poles or underground in conduit. Broadband amplifiers must be inserted in the cable about every 3500 feet to boost the signal level, and these are usually mounted on poles or in the school buildings themselves.

To maintain a uniform response over all channels of the system, equalization is included at each amplifier, since the attenuation of the coaxial cable is not uniform at all frequencies. Because coaxial cable attenuation generally increases in proportion to the square root of frequency, this equalization assures greater gain at the high frequencies. The equalization is adjusted to suit the different lengths of cable between various amplifiers. The attenuation of coaxial cable also varies considerably with ambient temperature, and such variation is more marked at high frequencies than at low — a phenomenon sometimes known as "tilt." This variation produces a considerable change in the signal levels of the various channel carriers on the system.

It is the objective of the system design to deliver all channels to the receivers at approximately the same level. Accordingly, the transmission level of some amplifiers is controlled automatically, and such control — under the action of a pilot frequency — acts to keep the gain of the system uniform. Other amplifiers are also equipped with automatic tilt control, which, because of the action of two pilot frequencies, strives to maintain a flat system response as ambient temperature changes occur.

Independent groups have performed many experiments to determine the best method of viewing the picture in the schools. Large-screen projectors would be desirable if the majority of

the programs were to be viewed in an auditorium, or by a large number of students in a lecture room. In general, however, 21-inch commercial receivers of various makes have been used in the classrooms at the rate of one receiver to approximately 20 students.

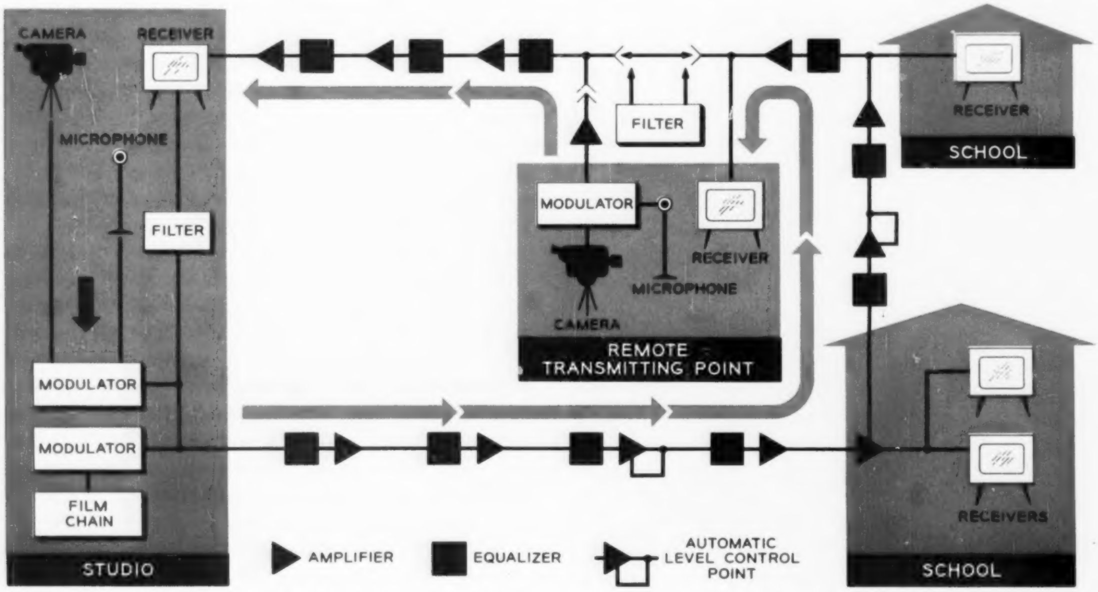
Some of the set manufacturers are beginning to furnish receivers built to standards of brightness and definition that are most suitable for classroom use. In general, the programs are displayed with the receivers tuned as required for normal television-channel frequencies. Since some programs may be transmitted over the closed-circuit system at lower than standard television-channel frequencies, converting units which would step up the frequencies may be required at certain of the receiving locations. As long as the receivers are connected only to the coaxial cable system, the programs received will be those originating in the system. However, any receiver can be switched to a local antenna for "off-the-air" pickup of broadcast channels.

"Talk-back" units, which permit selected students to question a TV lecturer during a program, are available to a limited degree. Though such "extras" tend to become quite complex where the number of receiving points is large, they can be furnished, as needed, in accordance with the ability of the user to administer them. In many instances, "feedback sheets" are used to relay the written questions of the students to the lecturer for answers during the next lecture.

Transmission considerations play a very large part in the effort devoted by the Laboratories to the improvement of systems similar to those discussed in this article. Picture quality is of first importance, and the criterion for judging the performance of a system of this type is that it shall provide a picture essentially unimpaired by background "noise" or distortion contributed by the transmission circuit. This means that the picture should be as good or better than that obtainable off-the-air from a local antenna.

Many of the transmission components furnished for closed-circuit systems by the Operating Companies were designed by non-Bell System suppliers for community antenna service. However, considerable improvement has been needed to meet the more exacting requirements of industrial and educational TV. These improvements reduce the distortions which tend to arise in a closed-circuit system. Such distortions appear in the picture as viewed on the receiver and originate from noise, cross modulation, "beat" frequencies and echoes.

Noise, the first of these distortion factors, results when a signal is allowed to become so weak that it enters an amplifier or receiver at a level too close to the level of random noise produced by the amplifier or receiver itself. Noise appears as "snow" in the background of the picture. To keep it to a minimum, amplifiers and receivers with a low "noise figure" should be used; also, input levels to the amplifiers should



Block schematic of "round-robin" type of system construction which permits transmission from a number of "pickup" points on the closed circuit to any of the receivers on that same closed circuit.

not be allowed to fall below a specified minimum. These requirements become more exacting as the length of the system — that is, the number of amplifiers — increases.

The second distortion factor, cross modulation, occurs when the video information modulated on one channel in a system appears in the picture of another channel. The amount of cross modulation produced by a system of this type is primarily a function of the linearity of the line amplifiers. It is also affected by the number of line amplifiers in tandem, as well as by the number of channels carried and the signal levels at the outputs of the various line amplifiers.

The cross-modulation effects are most severe when the modulations on the various channel carriers of the system are not synchronized with each other. This may give rise to what is known as the "windshield-wiper" effect — a vertical line moving horizontally across the picture of one of the channels. Such a phenomenon is caused by the modulation of the video information on one channel by the synchronizing pulses on another. Where "common sync" is used, this effect disappears — common synchronization being the signal pulse that coordinates the electron beams in the cameras of the various channels. To prevent other types of cross modulation, output levels at the various line amplifiers must always be kept below a maximum determined by the total of amplifiers in tandem.

The third distortion factor — "beat" frequencies — occurs as a result of interaction between the various carrier frequencies. These beat frequencies are sum and difference products, and their presence is indicated by "herringbone" patterns in the picture. They are also a function of line-amplifier linearity and of the levels at the various amplifier outputs. Such frequencies can be controlled to a large degree by the judicious allocation of the carriers in the available frequency spectrum. Their sum and difference products should either fall outside the band being transmitted, or in some portion of it where they cause a minimum of interference. Their effect can also be reduced by adjusting the various carrier levels with respect to each other.

The last distortion factor — "echo" — is produced by impedance discontinuities which reflect energy. They are objectionable when their amplitudes are excessively large and when they are sufficiently removed in time from the wanted signal and produced noticeable distortions in the picture. Echoes may be seen as fringes or rings around the parts of the picture where the texture of the picture changes abruptly, or as faint, displaced replicas of the scene. In a closed circuit of the type discussed here, there can be many small discontinuities causing echoes, and the sum of all their effects can be expressed in terms of a single echo having an equivalent interfering effect. This permits the total echo effect to be specified as a single number—the "echo rating."

A specified echo-rating objective is set up for each television transmission system. The objective is approached by adjusting the impedance match of the transmission components to each other and to the coaxial cable. Where two local closed-circuit systems are to be connected over an intercity facility, the design of each must be improved so that the echo effects of the entire connection will fall within the echo-rating objective.

The need to curb all the distortions described above — noise, cross modulation, beat frequencies and echo — now limits the length of signal path in closed-circuit systems to about 35 miles.

Considerable future demand for expansion of this type of service is expected. Each system installed contributes ideas which permit lower costs, transmission improvements, and new ways of making this medium more effective. Future systems will make greater use of color programs, since most of the transmission components are already engineered to permit this. Most of the systems already installed have found aerial outside plant to be satisfactory because of the areas in which they have been used.

As closed-circuit systems move into urban areas, however, more of the cable will have to be placed underground. This will call for the design of amplifiers that can be placed in manholes and left for long periods without attention — perhaps under flood conditions. For this purpose, transistorized amplifiers may greatly reduce maintenance and construction costs.

It is expected that considerable further development will be devoted to the improvement of both transmission and outside plant components. Amplifier housings (for open-view outdoor use), improved in appearance over those now in use, will soon be ready. Improved transmission components should further minimize the distortions described above, and thus increase the practicable distances over which these systems may be operated. The increased distances will make possible the combining of school districts to share both the expense and the benefits of closed-circuit educational TV. Such improved transmission arrangements for local closed-circuit systems will also make it feasible to link more of them together over intercity transmission facilities in larger networks.

The experimental electronic switching system (ESS) uses a semipermanent memory called the "flying-spot store." This unit stores bits of control data in the form of dots on small photographic plates, and employs unique mechanical, optical and electronic techniques for the retrieval of digital information.

D. C. Koehler and J. J. Madden

MECHANICAL DESIGN OF A FLYING-SPOT STORE

Tomorrow's telephone switching systems will undoubtedly use many new and unique electronic methods to connect the call of one customer to another. Today's switching systems are highly efficient electromechanical units in which switching is controlled by equipment like: registers to give dial tone and record numbers; markers, or master dispatchers; wired memory units for storing local numbers; and senders to forward information to other offices. Tomorrow's electronic switching system (ESS) will operate at a greatly increased speed as its master unit, or central control, is fed information by: a scanner that looks at incoming lines as often as 100 times per second, a temporary memory such as the barrier-grid store, and a semipermanent memory such as the flying-spot store. This new memory unit demanded the solution of many exciting mechanical problems.

Of all major components of the experimental electronic switching system, the flying-spot store is probably the most "mechanical." This unit is a photographic memory that "remembers" line-translation information and program information, both of which control the operation of ESS. Information is stored in tiny clear and opaque areas on photographic plates, and is recalled from the "memory" with a precise optical system and high-speed electronic circuitry. In addition to assuring large storage capacity with high-speed access, this memory meets requirements for efficient heat dissipation, high voltage insulation, and minimum crosstalk between critical circuits.

Mechanically, the "store" includes such items as large castings, lenses, light pipes, photographic plates, motors, and gears. One can see, therefore, that successful operation depends not only on the circuits, but it also depends very much on the

adequate solutions to the problems of applied physics and mechanical design.

An early model of an experimental flying-spot store is shown on this page. It consists of an optical system surrounded by electronic equipment housed in a single cabinet. Some of the electronic equipment is mounted on gates, which may be swung open as shown, for easy access to the wiring.

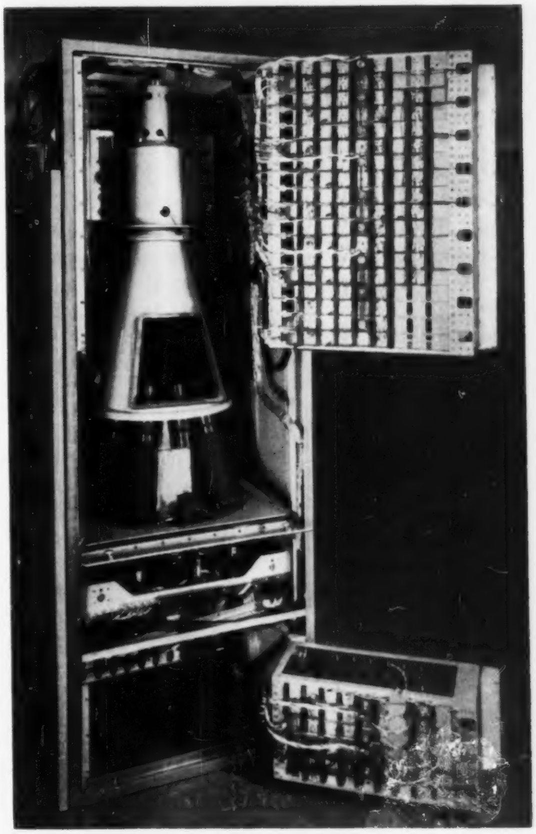
The Optical System

The optical system consists of a cathode-ray tube at the upper end, a system of lenses, photographic code plates and light pipes near the center, and photomultiplier tubes below. The cathode-ray tube, mounted face downward in a tube shield, is supported by the large, conical aluminum casting. Lenses, photographic plates and light pipes are also mounted on castings, which are precisely machined for accurate, stable positioning. The entire assembly is light-tight and dust-tight. For accessibility, the photomultipliers and associated amplifiers are located in a drawer below.

A spot of light at a particular X-Y coordinate position on the cathode-ray tube is projected on small areas of nine photographic plates through nine objective lenses arranged in a circular array around the periphery of the optical system. Such plates act as the memory of the system and contain both clear and opaque areas. When the light strikes a clear area, it is transmitted through the plate to a condensing lens below, and through this lens to a photomultiplier tube. The condensing lens is designed to form an image of the objective lens on the photocathode of the photomultiplier. This results in a stationary, circular spot of light on the photosensitive surface of the photomultiplier — regardless of the location of the spot on the cathode-ray tube.

The photomultiplier converts the light energy to an electrical signal which is amplified and identified as a binary "one." Plates that are opaque in corresponding areas do not transmit light, and the resultant lack of output is called a "zero." Since there are nine information plates, a nine-bit binary number is recalled from the memory for each coordinate position of the beam on the cathode-ray tube.

Two special cylindrical lenses *(see drawing on page 17)*, mounted near the center of the optical system, are used to monitor the position of the spot on the cathode-ray tube. These lenses are similar to the objective lenses in the information channels except that the surfaces of the glass elements are cylindrical rather than spherical. Such lenses project the spot of light from the cathode-ray tube in the form of line images onto



An experimental flying-spot store with hinged gates containing the program circuits (above) and registers (below); both of these units are swung open to show the optical system with its conical frame in the center and its nine paths.

two plates containing coded beam-position information. These are called "servo plates." The axes of the two cylindrical lenses are mounted at right angles to each other, and therefore the image lines on the two plates are also at right angles. Thus, any motion of the spot on the cathode-ray tube may be detected by a displacement of the lines on the servo plates.

Each servo plate has seven binary-coded areas, forming parts of seven position-indicating channels. The line of light simultaneously crosses all seven channels. Each channel defines a "one" or a "zero," depending on whether the light passes through a clear area or is blocked by an opaque bar, to result in a seven-bit binary number. The number from one servo plate is used to identify the X coordinate of the cathode-ray tube spot, and from the other the Y coordinate.

Light passed by each position-indicating channel is sensed by a separate photomultiplier. Because the servo plate is too small to mount all seven photomultipliers directly below it, a series of light pipes is used to convey transmitted light from the plate to the tubes. These pipes are methyl-methacrylate strips, each of which is bent to direct the light to the proper photomultiplier. The entrance edge is curved and acts as a cylindrical condensing lens; the exit end is beveled to act as a prism. This combination cylindrical lens, light pipe and prism directs the light to the center of the photomultiplier regardless of the location of the spot on the cathode-ray tube.

Access to Information

Information is recalled from the memory in the following manner: the central-control unit (which is the master control of an entire ESS operation) sends the desired X and Y address of the spot in binary form on groups of parallel leads to the X and Y input registers near the bottom of the store. These registers receive the current pulses identifying "ones" or "zeros," and store these binary numbers in flip-flops — that is, in vacuum-tube circuits having essentially two input and two output leads.

If the "one" input lead is pulsed, only the "one" output lead supplies a voltage. Correspondingly, if the "zero" input lead is pulsed, only the "zero" output lead supplies a voltage. Logic circuitry is then used to compare the outputs of the flip-flops (the required address) with the outputs of the position-indicating channels (the present address). If the numbers differ, error signals are sent to integrating and deflection amplifiers which move the spot in the direction of the desired location. When the two sets of numbers representing the desired location and the actual location coincide, the motion of the spot is stopped, and the outputs of the information amplifiers are sent to the output registers.

Thus, the spot is positioned by an electro-optical servo system which determines where the spot is and deflects it in the proper direction until the desired location is reached. This entire sequence of events — from the time the desired address is sent from central control until the output information is stored in the registers — is accomplished with cycle times as short as 2.5 microseconds. The store is directed through the proper sequence of operations by the sequence-control circuits, mounted on the upper gate.

The high-speed pulse circuits set stringent requirements on crosstalk and capacitance between critical leads. To control these factors, the highly repetitive circuits used in the register, servo and sequence control are mounted on printed-wire boards 3.6 by 9 inches. These are plugged into connectors that are mounted on the swinging gates for easy access to the wiring and optical system. To aid uniformity of operation further, all filament leads to the tubes are engineered to give a highly uniform voltage.

Other circuits, such as the integrating and deflection amplifiers, are mounted on chassis because of the large components required and the high heat dissipation. These deflection amplifiers have a special blower to help dissipate the 800 watts they generate. A special air-flow switch controlling the plate-voltage supply is incorporated in each deflection amplifier to protect its tubes if the blower fails. Another blower in the base of the cabinet creates a forced draft for general cooling of the electronic equipment throughout the cabinet.

The first step in preparing each memory plate in a dark-room is to slip an unexposed photographic plate into a metal frame where it is lightly held by spring pressure. Then the frame and plate are drawn into a container, which when closed is both dust-tight and light-tight. The container is attached to the store in room light. When the plate and frame are ejected into the optical system, the reference edges of the glass are pressed against precisely placed locating pins

J. J. Madden examines the "wobbulator" mechanism; this unit keeps the cathode-ray tube in slow but continuous motion to distribute wear of the electron beam on the phosphor surface.

and shoulders. Thus, the frame is used only for handling purposes, and although it remains in the store it does not affect the positioning accuracy.

The plate is exposed by a projected image of the spot on the face of the cathode-ray tube, which is programmed to move sequentially to each co-ordinate position in which it is desired to store a "one." This spot pauses for a controlled time at each of these positions, moving past areas where "zeros" are to be stored with deflection speeds sufficiently fast to prevent exposing these areas. After all required "ones" have been exposed, the slide and frame are removed from the store in the same container used earlier, and are returned to the dark-room for chemical processing.

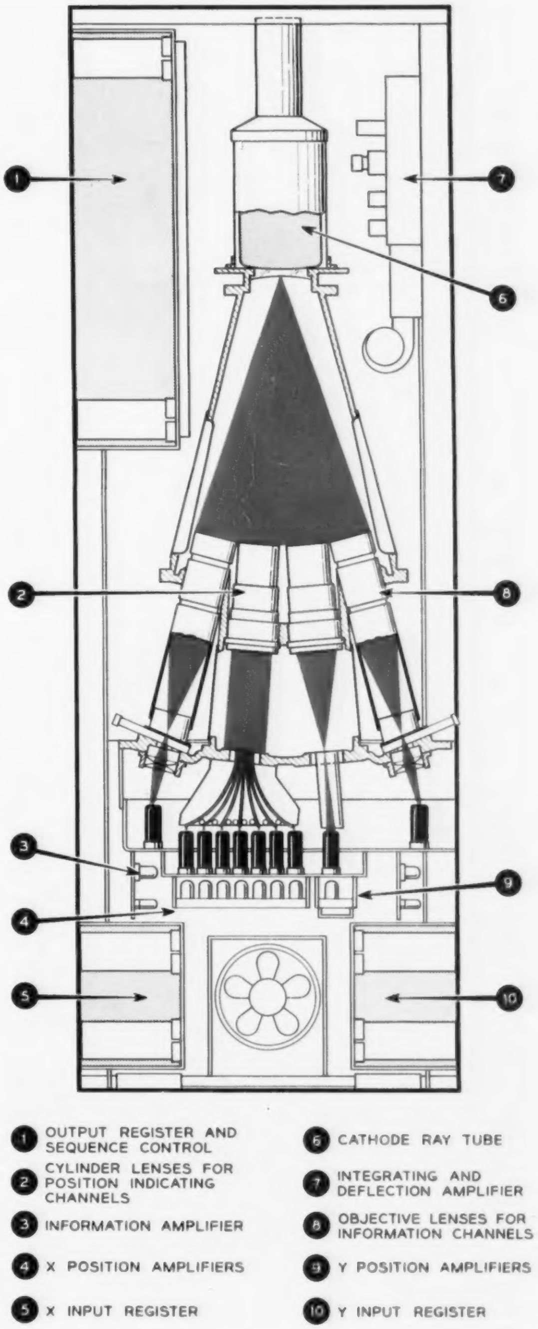
Plate and CRT Positioning

A special reversal process is used to produce clear spots in each of the exposed locations. The plate and frame are then repositioned in the store so that when the cathode-ray tube spot is deflected to the same locations that were exposed, the projected light will pass through the clear areas to the photomultiplier tubes. Proper registration of the projected spot image on the code-plate pattern is assured by the positioning technique, which automatically repositions the plate to within 0.0004 inch of its earlier position during exposure.

One of the limitations in the life of the cathode-ray tube is aging of the phosphor on the tube face. It becomes dimmer with increased use — although this degradation is partially restored with rest. However, all spot locations or addresses on the cathode-ray tube are not used with the same frequency. Hence, some locations age more than others to give different light intensities.

To minimize aging, a drive mechanism called the "wobbulator" — shown on page 16 — was devised to keep the entire cathode-ray tube in very slow but continuous motion in a plane parallel to the phosphor surface. The motion is simple harmonic with a total amplitude of $\frac{1}{8}$ inch in both X and Y directions, but with a frequency ratio of 12.5 to 1 between the two.

This article has attempted only to outline the mechanical nature of the semipermanent memory unit (flying-spot store) of the ESS system. Though the new system is electronic, many new and purely mechanical innovations were needed to make this latest Bell System experiment in electronic communications possible.



A view showing paths followed by light from a single spot in the center of the cathode-ray tube.

This lacquering machine can, in one continuous operation, deposit a precise plastic film on rolls of capacitor paper totaling one mile in length.

Semiconductor devices are promoting a size trend in all electronic components. Capacitors for example, are shrinking; yet they manage to store the same charge as their predecessors. Typical of these is a supported lacquer-film capacitor developed at Bell Laboratories which has the same capacitance as a mica unit twenty times its size.

H. G. Wehe and J. K. Werner

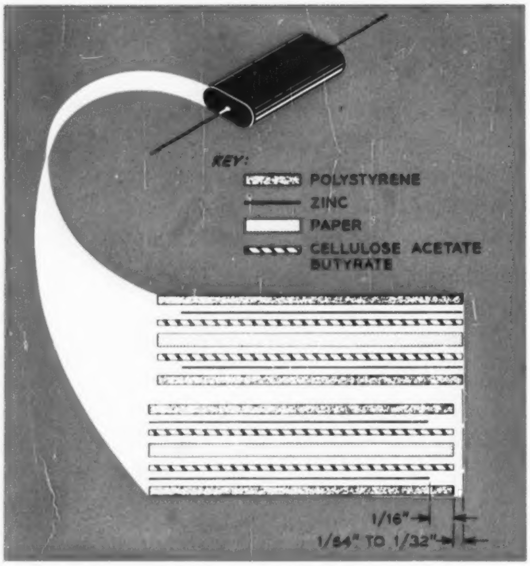
A Miniature Lacquer-Film Capacitor

Designers of modern electronic equipment continuously seek ways to put that equipment into smaller packages. But since they cannot let this miniaturization in any way reduce the quality of performance, they must use components for the circuits that are at least as reliable as their larger counterparts. A major breakthrough in this art came with the development of the transistor. And this was followed almost immediately by new developments in small complementary components such as resistors and capacitors. As a result, the Bell System has put to work many transistorized and other low-voltage circuits both in telephone and in military areas. The electronic switching system (RECORD, *October*, 1958) is an example of a potential large-scale application of these units. They also find use in the circuits of guidance equipment for missiles.

Typical of the developments in the field of reliable miniaturized components has been the lacquer-film capacitor developed at Bell Laboratories. Actually, the Laboratories originated two of these capacitors, which are made of thin metallized lacquer films rolled into cylinders. One is the "stripped" type whose strong, but very thin, dielectric of metallized cellulose acetate is stripped from its paper support before being wound into a capacitor. With a rating of fifty volts, it has properties similar to those of metallized paper capacitors, but is only one-fourth as large.

The other type, also rated at fifty volts, is the "supported" lacquer-film capacitor which was developed to specific requirements of the Signal Corps. This one derives its name from the fact that the support, as well as the lacquer film, is wound into the capacitor. Such an arrangement is essential for a substance such as polystyrene that is too weak mechanically to form self-supporting films of the desired thickness.

This supported lacquer-film capacitor, the subject of this article, was to duplicate in much smaller packages the characteristics of mica



To construct the miniature capacitor, two lengths of the seven-layered material are wound together so that each has an "unmetallized" margin at opposing edges. This arrangement prevents molten solder, sprayed on to make the terminals, from electrically shorting the two lacquered strips.

capacitors. This required first of all, a high "Q" or performance efficiency. It was to operate at frequencies of up to a megacycle, and its insulation was to have a high resistance under all operating conditions.

Further requirements included good stability in the temperature range from —55 degrees C to 75 degrees C and a long life expectancy. But the major problem revolved around the need to obtain over 25,000 $\mu\mu$f of capacitance in a volume of 0.03 cubic inch, with no dimension exceeding ⅝ths of an inch.

Faced with these requirements, Laboratories engineers set to work to design a supported capacitor made of a polystyrene lacquer film. They first decided the most satisfactory support would be capacitor paper. Although it was possible to use a support as thin as 0.00018 inch, it appeared more practical for the greater part of the development to use paper 0.00025 inch thick.

The next step was to deposit a lacquer film on the paper. Let us follow this process as it was developed by Laboratories engineers. Using a lacquering machine *(see page 18)*, an assembler lacquers the paper support on each side with a coat of cellulose acetate butyrate (CAB) — 0.00002- to 0.00004-inch thick. He can deposit on a CAB-coated support metal electrodes four times as thick as he could deposit on unlacquered paper, and can do this without losing either the sharp edges on the electrodes or clean insulating margins. The thicker electrodes reduce series resistance to improve the quality of the capacitors.

In the lacquering equipment, paper from a supply roll at the lower left of the equipment comes in contact with a roller wet with lacquer. This lacquer is immediately smoothed, and any excess is removed when the paper passes over a counter-rotating rod — commonly called a "doctor" rod. After being dried by infra-red lamps at the right and top of the machine, the lacquered paper is wound up on another roller.

The amount of lacquer applied to the paper is controlled by: (1) the solids content of the lacquer, (2) its viscosity, (3) the gap between the lower lacquer roller dipping in the trough of lacquer and the upper lacquer roller in contact with the paper, (4) the diameter and speed of rotation of the doctor rod, (5) the speed of the machine and the tension on the paper as it passes over the doctor rod. Crosswise variations in tension due to bagginess in the paper are equalized by a "floating" roller.

After removing the lacquered paper from the equipment, the assembler bakes it in a vacuum to remove remaining solvents and moisture. He then applies appropriately designed zinc electrodes to each side of the lacquered paper support. This is done by zinc coating the support, one side at a time, in vacuum metallizing equipment. The process calls for extreme care in aligning the edges of the electrodes so that the margin of one is exactly matched to its opposite number on the other side of the paper.

In the coating process, a trace of silver is first evaporated through a mask to provide the electrode pattern, and then the entire surface is exposed to zinc vapor. The zinc adheres firmly to the silver nuclei, but bounces off the lacquer at the margins that were shielded from the silver. The assembler applies sufficient zinc to give the electrodes an electrical resistance of about 0.5 ohms per square. (This means that the electrical resistance measured at opposite edges of a square of any size — one inch, one foot, one mile — is 0.5 ohms). Within limits, a lower resistance of the electrodes means less electrical loss (higher Q) in the resultant capacitor.

He next applies a coating of polystyrene lacquer 0.0001-inch thick to each surface of the metallized support. The thickness and uniformity of this lacquer must be carefully controlled, so again he uses the lacquering equipment. When this

step is completed, the assembly will consist of seven layers: the paper, cellulose acetate butyrate on each surface of the paper, zinc on each surface of the butyrate and polystyrene on each surface of the zinc.

To construct a capacitor from this seven-layered material, the assembler must first trim it to the desired width in such a way that the metal electrode is exposed on one edge and the insulated margin is exposed on the other. He winds two of these supports together and places them so that one has its unmetallized margin along one edge, and its mate has the unmetallized margin along the opposite edge. This is the so-called "extended foil" construction.

Molten solder, sprayed on the ends of the capacitor to form the terminals, joins together all the turns of each strip. The unmetallized margins prevent the sprayed solder terminals from shorting the two capacitor strips. However, the sprayed solder does join together the two zinc coatings on each strip, thereby removing the paper support from the electric field of the capacitor. Except for slight "fringing" effects, this leaves only polystyrene as the effective dielectric. Thus the paper is present mechanically but absent electrically in the capacitor.

Prior to winding, the assembler starts each flattened rectangular capacitor with a paper core, and after the winding is completed he covers the unit with paper to protect it mechanically. After applying the sprayed solder terminals and attaching the tinned copper leads axially by soldering, he wraps each capacitor unit in a plastic wrapping of polyethylene terephthalate to insulate the outer sprayed-solder terminal from the nickel-silver container. One lead projects through the insulating top seal of the container, while the other projects through a hole in the bottom of the can. This hole is soldered closed after a thorough baking and vacuum drying.

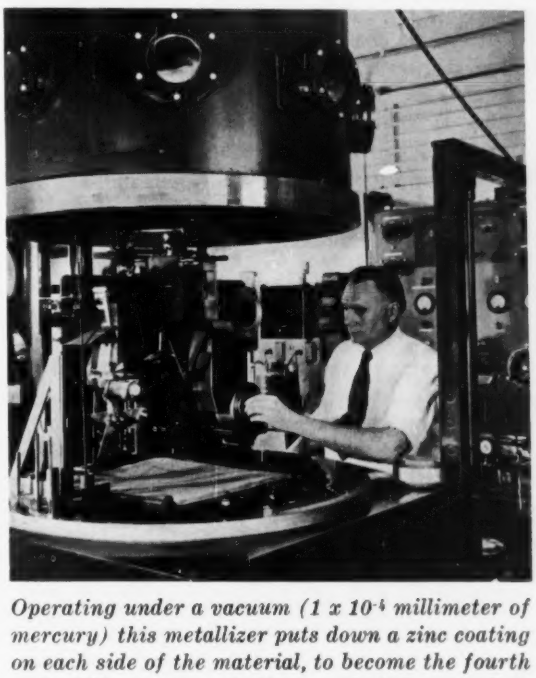
After being sealed, each completed capacitor is given a number of tests. In the first of these the assembler discharges a 30 μf capacitor charged to a low voltage through the capacitor and then applies 100 volts dc for ten seconds. This clears the units of short-circuits by isolating the weak spots through the fuse-like action of the thin zinc electrodes. He then stabilizes the capacitors by exposing them to ten temperature cycles, extending from —55 degrees to 75 degrees C, and then aging them from 100-300 hours at 65 to 75 degrees C and 100 volts dc.

The original capacitors were characterized and evaluated by life tests extending beyond 4000 hours at various temperatures and voltages. The final test program was established at the Laboratories with the help of a statistical analysis of the preliminary data.

Final results showed that capacitances up to 35,000 $\mu\mu$f (40 per cent more than the 25,000 $\mu\mu$f originally sought) could be satisfactorily made and housed in a volume of 0.03 cubic inch. By exercising control over the thickness of the polystyrene lacquer dielectric, manufacturers can adjust this capacitance from approximately 10,000 $\mu\mu$f to 35,000 $\mu\mu$f or more without changing the over-all volume; the lower the capacitance the thicker the lacquer and the better the operating performance. The results reported in the following paragraphs were obtained on capacitors having about 35,000 $\mu\mu$f capacitance.

For these units the effect of temperature cycling was slight. During the first 10 cycles the change in capacitance was less than plus or minus 0.5 per cent, and the change in Q less than plus or minus 5 per cent. The resistance of the insulation actually improved.

After 10 temperature cycles, engineers studied the effect of temperature variation over the tested range. Temperature proved to have a relatively small effect on capacitance, and the temperature coefficient, although variable, was generally negative and less than 100 parts per million per degree C. Temperature has an appreciable effect



Operating under a vacuum (1×10^{-4} millimeter of mercury) this metallizer puts down a zinc coating on each side of the material, to become the fourth and fifth layers of the supported capacitor.

on insulation resistance, but though this falls with increasing temperature, at 75 degrees C it remains satisfactorily high.

The performance efficiency of these capacitors is fairly constant up to frequencies of approximately 100 kc, showing a relatively small decrease at these frequencies. Above 100 kc, however, the Q starts to fall more rapidly. In spite of this, even at 1000 kc, the Q is greater than a minimum requirement of 650 set for 200 kc. Laboratories engineers determined the Q could be still further improved by decreasing the electrode resistance, by increasing the dielectric thickness, or by reducing the width of the electrodes.

The engineers also made life test studies on more than 200 capacitors built from various films at temperatures varying from —55 degrees C to 95 degrees C and at voltages ranging from 25 to 100 volts dc. They found, for example, that at temperatures around —55 degrees C the capacitors were very stable. At 21 degrees C the capacitance increased steadily (at approximately 0.7 per cent per 1000 hours during the more than 4000 hours on test). At temperatures of 65 degrees C and above, however, the capacitance stabilized quickly (in less than 200 hours). Once stabilized, it changed very little (about 0.2 per cent in the 4000 hours) unless the voltage and/or the temperature changed. If a change in ambient conditions occurred, the capacitor adjusted quickly to the new conditions by a small change of less than one-half of one per cent in capacitance. However, it became steady again after this change.

The Q changed relatively little during the lifetime of the test. For more than 4000 hours at voltages up to twice the rated voltage, the electrical losses remained low, well below the desired limit at temperatures of 75 degrees C and lower. At 95 degrees C, the change was a bit more rapid but remained below the desired limit.

In general, the resistance of the insulation remained satisfactory throughout the life tests, usually staying above the arbitrary limit of 1000 ohm-farads. Even when it dropped appreciably below this value, the capacitors did not short out.

The results of these tests indicate a successful achievement of the initial requirements for a miniature capacitor whose properties approximate those of a mica capacitor. The supported lacquer-film capacitor has a low loss factor up to the megacycle region in frequency, a high insulation resistance, and a fair stability on life test. Furthermore, for 50-volt use it contains twenty times as much capacitance in the same volume as a comparable mica capacitor.

Alumina Powder Used to Protect Electronic Components

A basically new approach in the protection of electronic components was revealed last month by L. W. Kirkwood and R. S. Key of the Military Component Development Department. They described how alumina powder — a form of aluminum oxide — can insulate, or "pot", transformers and other electrical components within hermetically sealed cans. It would replace the more conventional semifluid materials, such as mineral-filled asphalts, used in the past.

This new development was announced in a paper presented at the National Conference on Application of Electrical Insulation in Washington, D. C. The first use of alumina for potting was made by H. S. Feder, of the Special Systems Development Department, who developed the application.

In many cases, electronic and electrical components must have extra protection from extremely humid environments. A common practice is to seal these components hermetically inside a metal can. However, when the component is enclosed in this way, its internal temperature increases to a point where the life of the device is seriously reduced.

Conventional practice, therefore, calls for including a "heat-transfer" material in the can to carry the heat from the device to the can, and thence to the air, to reduce this increase in temperature. Materials used for this purpose are called "potting compounds."

Popular conventional potting compounds include mineral-filled asphalts such as sand asphalt. This material has good heat-transfer properties, but it melts at relatively low temperatures (135 to 150 degrees C). When it melts, it expands, threatening the hermetic seal and often damaging the component.

Alumina powder does not have this disadvantage. Its melting point is over 1500 degrees C — well above the operating temperatures of any electrical apparatus. No strains are imposed on the component, because the alumina does not expand or contract noticeably under wide fluctuations of temperature. Some plastic potting compounds do need special treatments, such as vulcanizing, and these often result in component strains.

The powder possesses another unique advantage over asphalts, epoxy resins, and other similar potting compounds. It maintains its dry, granular form in use. Thus, the electrical component can be removed simply by breaking the seal and pouring out the powder.

Alumina is completely inert. Thus, there is no fire hazard, either during potting operations or in use, in contrast to inflammable asphalts or resins. And, since alumina is stable to relatively high temperatures, it can be used in different applications to cover the gamut of temperature ranges.

The preferred physical form of the alumina is spherical. In this shape, the granules pack well, but do not have the abrasive characteristics of more irregular shapes. Material of this type is available at prices competitive with conventional materials.

Some customers may prefer a handset that, in addition to the transmitter and receiver, also includes a dial. In what could be an important new design for the future, Bell Laboratories has built an experimental Dial-In-Handset telephone that offers this dialing convenience and meets rigid operation and transmission requirements.

W. E. Whidden

An Experimental "Dial-In-Handset" Telephone

During the last few years, customer demand for new telephone instruments and services has been increasing rapidly, stimulated by the vigorous merchandising campaign of the Bell System. A number of these are already available, such as the small Princess Telephone Set, the Call Director, the Telephone Answering set and the Speakerphone. A home communication system is just now becoming available. In addition, a push-button dial set is on field trial, and a new, smaller wall set will be ready for trial later this year. Many other projects are in various stages of development, such as panel-mounted telephones, desk-drawer sets, a small executive set and a patio telephone set.

One of the more radical concepts being explored involves a change in the use of the telephone. That is, it might be possible to bring the dial to the user by incorporating it in the handset. This has led to consideration of a drastic departure from previous ideas of what a handset should look like.

The basic appearance of the handset has not changed appreciably since its introduction in 1928, but improvements in the art have of course made the present handset functionally far superior to its predecessors. The end result has been a lightweight, efficient and trouble-free instrument which, together with its mounting, has provided the customer with a telephone set of pleasing appearance and easy operation. However, there are particular applications where the advantages and the added convenience of a Dial-In-Handset telephone are immediately apparent. In bedroom installations, for instance, such an instrument would permit easy dialing while lying down, or in drive-up coin stations, where the handset is brought into the automobile, it would

eliminate the necessity to reach out for dialing.

There are several possible locations for mounting the dial in a handset. The standard lineman's handset has the dial located at the back of the instrument at the receiver end. Another possibility is to mount the dial finger-wheel concentrically around a small transmitter unit. This arrangement appeared attractive, but it would require both a new transmitter unit and a small dial designed to meet severe system requirements for large-scale usage. Still another Dial-In-Handset, a European design, stands upright with the dial located in handset base. All of these dial positions have one or more disadvantages, such as difficulty or awkwardness in dialing or an unbalanced distribution in weight.

The Importance of Dial Location

Locating the dial between the transmitter and the receiver overcomes most of the difficulties. Since the dial can be recessed in a cavity, the needed mechanical protection is obtained automatically, and inadvertent rotation of the dial is minimized. The ultimate shape and form of the experimental handset was proposed by the industrial designer, Henry Dreyfuss, and was determined to a large extent by the dial location. In this arrangement, the handset shell is contoured to fit the hand, with the dial nesting snugly in the palm — a very convenient, stable position for holding and dialing. With the basic form of the handset thus established, a compatible base was developed, resulting in a much smaller telephone with a distinctively different character.

The handset is molded in two pieces — a boat-shaped shell and a cover plate. All of the components — the transmitter, receiver, dial and dial light — are mounted on the cover plate. The two parts are fused together to form a complete handset. For maintenance, the dial and the retractile handset cord are accessible and replaceable through the dial cavity. The transmitter and receiver are permanently sealed in, but since these components are essentially trouble-free items, the need for servicing or replacement is extremely low.

The lamp for the dial light is placed in the region near the 8 and 9 holes of the fingerwheel. It is readily replaceable by the customer without special tools. All he needs is a small coin. The dial number-plate is a relatively thin piece of acrylic plastic material that is edge-lighted by the lamp, illuminating the dial characters uniformly over the entire number plate area. There is a choice here of using light characters on a variety of dark-colored backgrounds. In any case, alternative background cards can easily be substituted to harmonize with the color of the set. The lamp also serves as a night light for subdued illumination to locate the set in the dark.

The dial was developed by the Laboratories group at the Indianapolis location, specifically for this application. Weight has been minimized, and a new high-speed governor has been provided. Unlike present dials, which are firmly mounted in a fixed position on desk or wall housings, this

This group picture shows recent trends in handset design. Two earlier designs, in black, are shown at left. Group at right consists of 500-type set with dial, experimental unit with push buttons, Princess Set, top, and new experimental Dial-In-Handset. The Dial-In-Handset is the first radical departure in handset design.

Miss Barbara Weiss of the Laboratories tries the new Dial-In-Handset. At her elbow is the new Princess Set, and at the left is an experimental panel model mounted with its base flush with wall.

new dial must perform properly in all positions. The dial finger-wheel and the finger-hole diameters are slightly smaller than on the standard dial, but the wheel and the holes have been so shaped that dialing is easy and comfortable.

The transmitter is the T-1 unit used in the present standard handset. The receiver unit is new and its weight is roughly one-half that of the U-1 receiver, a saving of about 40 grams. This, of course, is an important consideration in handset applications.

The customary circular receiver and transmitter screw caps, with their annular pattern of holes, are no longer necessary in the new handset. The integral cover plate permits a wide choice of patterns. As seen in photograph on this page the transmitter openings are louvered and somewhat elliptical; the receiver openings are narrow slots which were designed to provide the proper acoustic load on the instrument. Other opening patterns of the same general character, but of slightly different shape, appear equally attractive. The distance between the transmitter and the receiver, and the angle of the planes of the transmitter and receiver diaphragms, are identical to those in the standard handset. These dimensions are based on the size and shape of the human head and on rigid transmission requirements.

The new handset, including the dial, weighs 12.4 ounces, a little lighter than the standard black phenolic handset (12.5 ounces), but heavier than the color handset (10.1 ounces). Further design work is expected to reduce the weight slightly. The cord must of necessity be somewhat larger than that of conventional handsets, since four additional wires are required for the dial and dial light.

In the on-hook position, the handset rests on a small base housing that has a low, sloping silhouette. All exposed surfaces are smooth, simplifying the dusting problems for fastidious housewives. The base area is oval in shape and about half that of the 500 set. The over-all height, including the handset, is 3-1/2 inches compared to 4-3/4 inches for the 500 set. The substantial reduction in all dimensions, which makes the new set particularly suitable for small tables, also required a rearrangement of the set components and a complete redesign of the switch-hook. In addition, a high degree of flexibility has been maintained in the basic set so that a number of special service features can be added according to the needs of the customer. Among these are a two-line pick up, an exclusion or hold feature, and switching for a home communication system.

Other Features

The new set could be installed either horizontally on a desk or table, or vertically on a wall surface. Stable, vertical hang-up is obtained by the matching contours of the squared off, inner part of the receiver cap and the exposed part of the switchhook.

The new experimental set has not been officially named, and until a more appropriate and distinctive name is suggested, it is being called the Dial-In-Handset telephone. The service objectives have been met and the preliminary design is finished, resulting in the unique free-flowing form. Preliminary results of a product trial indicate a high rate of customer acceptance of this radically different instrument. The design prospects look very promising — it is indeed an example of designing for the future.

Significant to the Bell System's philosophy of missile guidance is the continuous interplay of information among the radars the missile and the target. In the Nike Ajax system, this information is processed by a specially adapted analog computer.

W. E. Ingerson

THE NIKE AJAX COMPUTER

The Nike Ajax computer is one of a family of anti-aircraft analog computers developed at Bell Laboratories and produced by the Western Electric Company. The first of this series was the M-9 Anti-Aircraft Director, developed early in World War II to control the fire of 90-mm anti-aircraft rifles. This was followed by designs matching the external ballistics of a number of guns, both British and American. They were very successful throughout the war, particularly against the V-I "buzz bombs." The Nike Ajax computer is a direct descendent of these by way of an anti-aircraft fire-control system developed after the war.

The Nike Ajax guided missile system (RECORD, *February,* 1959) uses ground guidance equipment consisting of three radars and a computer. These are mounted on trailers and interconnected with semi-automatic methods of communication. The acquisition radar obtains coarse position data on target aircraft. It passes coordinates of a designated target to the target-tracking radar, a unit which furnishes to the computer precision information on position in three coordinates.

A similar precision radar, the missile-tracking radar, tracks the missile from before it leaves the launcher to the time it intercepts the target, and furnishes to the computer position data on the missile. Using the data from the two radars on target and missile, the computer solves guidance equations and develops appropriate acceleration commands. These are sent to the missile over the radar beam of the missile-tracking radar.

The basic techniques employed in Nike analog computers designed at the Laboratories have remained relatively unchanged for a decade and a half. Of course, there have been refinements, improvements in speed and accuracy, and elimination of the need for many adjustments and controls. But the basic techniques are much the same

as those used by a Laboratories team in 1941, which adapted techniques of telephone transmission for an electromechanical computer used as an automatic sound-level recorder.

Fundamentally, analog computers mechanize the mathematical operations of addition, subtraction, multiplication, division, differentiation, and integration. They generate functions, solve algebraic and trigonometric equations, and smooth data according to some accepted statistical regimen. In an analog computer many of these processes occur simultaneously, as contrasted with a digital computer where usually one mathematical process must be completed before the next one can proceed. For this reason, seventeen years ago it was possible to solve the anti-aircraft problem with analog machines while the game was going on. Digital machines are just now getting fast enough to handle such a problem.

In the Nike Ajax computer, addition and subtraction are done with high-gain, electronic amplifiers. The characteristics of these amplifiers are such that the output is equal, very precisely, to the sum of its inputs. The computing amplifiers are all identical. Yet they can be made to function as differentiators, integrators, data smoothers and control-loop equalizers through modifications in the electrical networks with which they are associated.

Most functions are generated with precisely shaped potentiometer cards. A number of these are "ganged" to make electromechanical servos which solve simultaneous equations. The brush voltages derived from the potentiometers are summed in a dc amplifier whose output, used as an error voltage, drives the servo toward a solution. A number of servos work together, solving interrelated equations simultaneously.

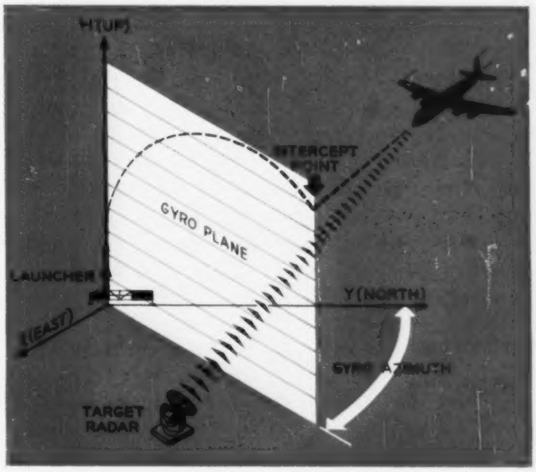
An important use of shaped potentiometers is in coordinate resolution. Here, they convert polar coordinates, measured by the radars, to Cartesian coordinates which are more easily handled by the computer. Additional resolutions rotate steering information into the coordinates of the reference frame carried by the missile.

The problem the Nike Ajax computer must solve is similar in many respects to that solved by its forebears, the anti-aircraft gun directors. Given the position of a rapidly moving target, the computer must compute the velocity of the target and calculate the position in space where it can be intercepted by the projectile. The computer must then compute the aiming information, so that the projectile will be propelled in the right direction. Finally, it must compute the time required for the interception to take place, and arrange for the projectile to explode at the propitious instant to destroy the target.

In the case of the gun director, all calculations prior to firing are carried out with the greatest accuracy possible, since once the shell leaves the rifle the computer has no more control over the situation. It has pointed the gun to the best of its ability and has given the shell instructions on the time to explode in the form of a fuse setting.

The problem for an anti-aircraft guided missile is somewhat different because here the computer continues to aim the projectile during its flight and continues to compute the remaining time to intercept. This difference results in relaxing requirements in some areas, and tightening them in others. For example, the estimates of intercept position *prior* to the launching of the missile need not be extremely precise. Nevertheless, due to longer ranges, the information on position and velocity must be better than that for the gun director. Also, in the case of the guided missile, a "grand feedback loop" must be closed around the missile guidance and attention given its stability.

The problem of missile guidance comprises three phases. The first, called the "pre-launch" phase, it quite similar to the anti-aircraft gun problem. The geometry of this problem is shown in the diagram on this page. During this phase, the computer receives position data on the target from the target-tracking radar. Then, by differentiation, it determines target velocity, a value



Before the missile is launched, the Nike Ajax computer determines the intercept point of the missile and target. It does this from information it receives from the target-tracking radar, and which it resolves into rectangular coordinates.

A. W. Sumner, left, and W. E. Ingerson at an amplifier bay of the Nike Ajax computer. The unit in the center is a "zero set" switch used to continuously adjust amplifiers to eliminate drift.

it multiplies by the time of flight of the missile to intercept. The prediction vector is then added to the target position to determine the intercept point that would be obtained if the missile were fired immediately.

Obviously, all this involves the simultaneous solution of several equations, since the intercept point must be known to compute the time of flight to it, and the time of flight must be known to determine the continuously moving intercept point. Having determined the coordinates of the intercept point, the computer calculates the angle in the ground plane at which the intercept is expected to take place. This "Gyro Azimuth" is used to position a gyro in the missile, giving it a reference frame it can later use to interpret the steering orders from the computer.

The second phase is called the "early-flight" or "initial-turn" phase. This is the time elapsed between launching the missile and the point at which it has turned onto a trajectory to the intercept point. In the case where the intercept takes place on the side of the launcher opposite from the radars, this phase amounts to a computer instruction to the missile to turn into the general direction of the intercept point. An additional feature of the initial-turn phase of the computer's operation is that if the missile for any reason starts to turn in other than the desired direction, the computer becomes aware of it, and issues appropriate commands to correct the situation.

After the missile has had an almost vertical launch, the computer turns it toward the intercept point. When it has turned over far enough so that it is on a semi-ballistic path toward the intercept point, circuits in the computer sense that it is "on trajectory," and the computer switches to the third or "steering" phase.

In the steering phase the computer uses the position information on both missile and target to derive relative velocity and set up steering equations in three dimensions. From these equations, the computer generates acceleration commands for transmission to the missile. These commands properly orient the flight path to intercept the target.

The steering equations are derived from the measured positions and velocities of target and missile. These are rotated into a coordinate system that agrees with the inertial reference the missile carries with it. Error components exist in the yaw and pitch directions and in the direction along the missile velocity vector. Steering errors in the yaw and pitch directions are used to develop appropriate acceleration commands that steer the missile. But the third component of steering error, along the missile velocity vector, cannot result in a corresponding acceleration because the missile cannot change its speed. Thus, the steering error in the velocity direction is used to re-estimate the time to intercept in the computer.

The "Grand Loop"

The missile guidance operates as a complex closed loop feedback system. Target position, obtained from the target radar, is introduced as an input signal to the loop. Missile position, obtained from the missile radar, is compared with target position, and the velocities of both vehicles are derived in the computer. From the relative positions and velocities, the system develops and transmits acceleration commands to the missile on the beam of the missile radar. The missile responds to these commands by altering its position. Thus, acceleration commands, which are the output of the computer, result in a change in the input to the computer — missile position and velocities. A "grand loop" is thereby closed around missile, missile radar, and computer. In any closed loop system, designers must give due consideration to the stability requirements. To avoid commanding the missile to fly an erratic course, it is necessary to "smooth" the data, or take an average over a period of time.

But averaging over a period involves delay, and delay in a closed loop system has an unfavorable effect on loop stability. In the Nike Ajax computer, the data smoothing functions were carefully chosen with over-all loop requirements in mind. In addition, the computer uses loop equalizing networks to avoid instability and poor response. These loop equalizers are applied to the developed orders before they are transmitted to the missile.

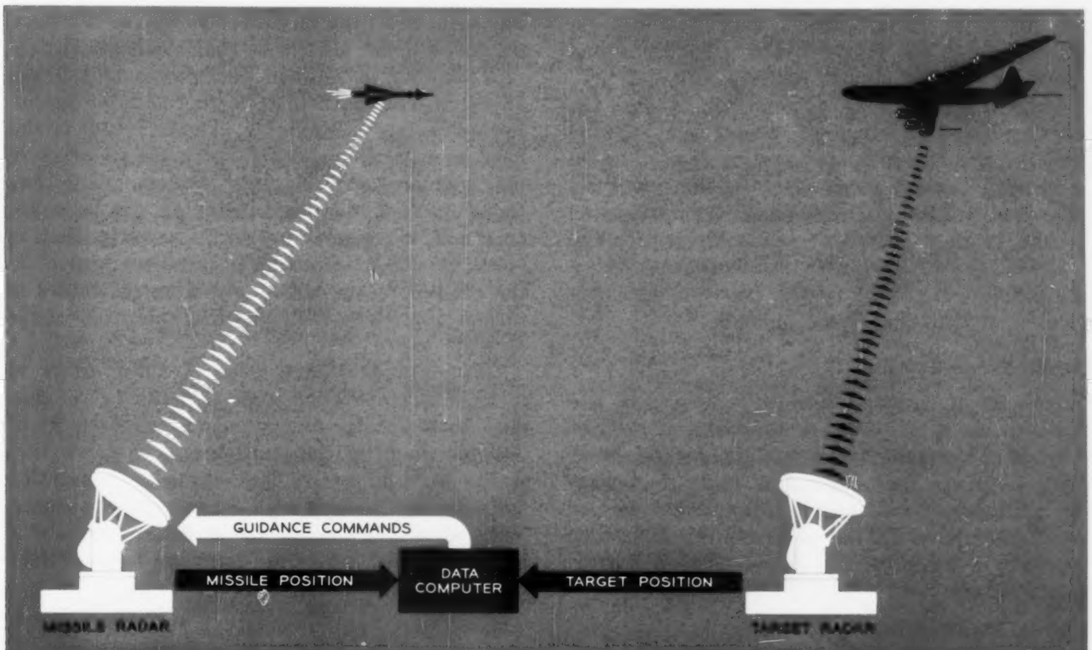
The computer also automatically applies a limit to the orders that can be sent to the missile. The amount a missile can maneuver without stalling or tumbling is a function of its altitude and speed. In keeping track of these values, the computer develops a limit, applied to the orders before transmission, so that the missile will never be commanded to execute a maneuver it cannot handle.

The dc amplifiers used in the Nike Ajax computer are monitored in groups by a commutator-like switch which samples the voltage at the input grid of each amplifier in turn. If this voltage differs from zero, compensating voltages are continuously developed to "zero set", or adjust, the amplifiers to eliminate drift. This ensures the maximum computing accuracy. Whenever an amplifier cannot deliver the exact output voltage required of it, suitable warning lights alert the operator. In addition to a warning, this arrangement provides a powerful trouble-shooting tool.

The basic-data potentiometers develop target and missile position voltages from radar shaft positions. Although physically mounted in the radars, they are functionally a part of the computer. These potentiometers are unusual in that they are the largest and most accurate wound-card potentiometers ever built. Each radar uses three of them — one each for range, azimuth and elevation.

Since the data potentiometers have a fairly high impedance, and are located several hundred feet from the computer, electrical leakage from the brushes was potentially a serious problem. This was overcome by a technique known as "driven shields." In this method, a properly selected voltage equal to the brush-lead voltage is applied to a shield completely surrounding the sensitive brush lead throughout its length. Thus, any leakage can be to only a point held at the same voltage, reducing its effect many times.

In the Nike Ajax system, the computer is housed in three bays along a wall of the battery control trailer. These comprise the power, amplifier and servo bays. Meters and controls are mounted on the front panels of the bays, near



The computer receives position data from both target and missile. From this, plus other stored data, it then generates and sends appropriate commands to the missile via the missile radar.

P. L. Hammann, left, watches K. W. Bauereiss adjust a cam-operated microswitch. Device is an integral part of "time-to-intercept" servo, the larger unit in drawer mount.

the top. After initial settings, very little manipulation is required of the controls during actual operation — it is almost entirely automatic.

Output signals of the computer become the plotting-board displays of target and missile position, and the computer's estimate of time-to-intercept. The primary outputs of the computer, of course, are the instructions it develops for the missile. Before launch, it sends instructions to position the roll gyro in the missile. And during the missile's flight, of course, the computer provides it with acceleration commands.

Other Procedures

Both the gyro azimuth and the fin orders are displayed on synchro-driven dials and meters, in front of the computer operator. In general, however, these are just qualitative indications that the engagement is proceeding normally. In the event of failure of the gyro setting link, the appropriate heading may be telephoned to the launching area where operators can set it manually. However, the fin orders as well as the burst command, must always be sent automatically.

A number of built-in test problems and self checking features help keep the computer operating accurately and reliably. The computer is also used as a precision tool to check the accuracy of the primary-position data system. The two radars, target and missile tracking, can be locked on the same target or set to the same position in space by dials. "Position difference circuits" in the computer then act as precision indicators in monitoring the over-all positional accuracy of the data system.

Designers devoted a great deal of effort to make this complex computer as accurate, reliable, easy to maintain, and simple to understand as possible. During the more than five years that it has been in use, it has earned a reputation for doing its job well with a minimum of trouble. The young soldiers who operate and maintain it have developed a genuine fondness for the Nike Ajax computer.

Oliver E. Buckley
1887-1959

Dr. Oliver E. Buckley, former President and Chairman of the Board of Bell Laboratories, died on December 14, 1959, in Newark, New Jersey. One of the nation's outstanding scientists and administrators of industrial research, Dr. Buckley retired from the Laboratories in August, 1952, after a 38-year career in Bell System research and development.

A native of Sloan, Iowa, Dr. Buckley received the B.S. degree from Grinnell College in 1909, and the Ph.D. from Cornell University in 1914. He joined the Western Electric Company in 1914, as a research physicist. When the Western Electric Company's engineering department became Bell Laboratories in 1925, he was appointed Assistant Director of Research. In 1933 he was named Director of Research and in 1936 Executive Vice President. He served as President of the Laboratories from 1940 until 1951, when he was elected Chairman of the Board. He held the latter post until his retirement.

Dr. Buckley also served on many government-sponsored technical and scientific committees. He was a member of the General Advisory Committee of the Atomic Energy Commission from 1948-54, was first chairman of the Science Advisory Committee of the Office of Defense Mobilization, and was a member of the National Inventors Council. He received the Medal for Merit, the nation's highest civilian award, in recognition of his contributions during World War II.

One of his outstanding contributions was his pioneering work in submarine telephony. The transoceanic telephone cables which now connect continental United States with Europe, Hawaii, Alaska and Cuba owe their origin to the inspiration of Dr. Buckley's early research.

At the end of World War I he began this work, particularly on the problem of increasing message capacity by the application of new materials and techniques. He and his associates also carried on research on a loaded cable for transatlantic telephone transmission, which resulted in a successful trial in the Bay of Biscay in 1930.

Although increasing executive responsibilities prevented Dr. Buckley from engaging in further research on submarine cables, he never lost contact with the development work initiated under his direction. This work eventually resulted in a telephone repeater sturdy enough to be submerged at great depths, equipped with electron tubes and other components reliable enough to operate unattended for many years. These developments made possible the present transoceanic cables.

Throughout his career, Dr. Buckley was associated with many professional and learned societies. He was a Fellow of the American Physical Society, the American Association for the Advancement of Science, the Acoustical Society of America, the American Academy of Arts and Sciences, and the American Institute of Electrical Engineers, of which he was vice president from 1946 to 1948.

He was also a member of the National Academy of Sciences, the New York Academy of Sciences, the Franklin Institute, and the American Philosophical Society, which he served as vice president in 1954-55. He was elected to Phi Beta Kappa, Sigma Xi and Phi Kappa Phi. He was a member of the Engineering Foundation Board from 1938-50, serving as chairman from 1939 to 1942. In addition, he served on committees for Case Institute of Technology, Columbia, Harvard, Princeton and Cornell.

He was a trustee of the Thomas Alva Edison Foundation and the Jackson Memorial Laboratory, and was a director of the National Multiple Sclerosis Society, which he had previously served as vice president and chairman.

Dr. Buckley was awarded the Edison Medal of the A.I.E.E. in 1954. He held honorary degrees from Grinnell College, Columbia University and Case Institute of Technology.

NEWS

New Mexico Site Will Test Effects of Alkaline Soil on Buried Plant Equipment

Bell Laboratories has bought 15 acres of New Mexico farmland where a "crop" of about 12,000 samples of telephone materials and equipment will be "planted" as part of an unusual long-range testing program. The unique new "farm" near Hagerman, a small rural community 18 miles from Roswell, is called the Roswell Environmental Test Plot.

This will be the second of two plots set up for the Laboratories "outside plant materials and structures soil burial program." In the fall of 1958, about 11,000 telephone items were buried in a similar Laboratories-owned plot near Bainbridge, Ga. (RECORD, *February*, 1959).

The test plots represent two general types of soil conditions found throughout much of the U. S.; between them are many variations. The soil at Roswell is alkaline and generally typical of soils in drier areas of the West. Bainbridge has acid soil and is in a region of high rainfall.

Workmen will begin burying specimens at the Roswell plot this spring, with a cover crop to prevent soil erosion after the burial work has been completed. A protective fence will circle the property.

Present plans call for digging up representative samples of the materials and equipment in both test plots after periods of approximately 1, 2, 4, 8, 16 and 32 years to see how they have withstood the rigors of being buried directly in the soil.

The same types and numbers of samples are to be tested in both plots. About 10,000 small specimens—mostly laminates, adhesives, plastics and various kinds of rubber — will be buried at Roswell. They will be attached to vertical polyethylene rods for burial at six and 18-inch depths. Test materials applied as insulation on two thousand wire coils, with voltage on half of them, will be put underground.

In the remainder of the tract will be various larger pieces of telephone apparatus. These will include several 200-foot lengths of cable connected to an electrical power source and laid in undulating lines to see how they will react to burial at different depths.

The samples undergo various tests before burial. They will be put through the same tests, for evaluation purposes, when removed from the ground on the scheduled inspection dates.

The Laboratories program stems from a growing interest in "buried distribution," the burial of telephone wires and cables without the extra protection provided by conduits (RECORD, *March*, 1959). Data obtained through the burial tests will help Laboratories scientists evaluate cable and wire structures and basic materials that will be placed directly in the ground for buried distribution.

Richard A. Connolly of the Outside Plant Development Department will conduct the inspections and will supervise installation and removal of specimens. The Mountain States Telephone Company is cooperating with the Laboratories on the project and will oversee maintenance of the tract after the burial work is completed.

John B. DeCoste, left, and Richard A. Connolly examine small strip of plastic similar to those to be buried in Roswell tract. Samples are attached to polyethylene rod for burial at 18- and six-inch depths.

Harry Nyquist To Receive IRE Medal

Harry Nyquist, who retired from the Laboratories in 1954, will receive the 1960 Medal of Honor, the I.R.E.'s highest annual technical award in the field of electronics. He will be honored for "fundamental contributions to a quantitative understanding of thermal noise, data transmission and negative feedback."

Mr. Nyquist, who had been with the Bell System for 37 years at his retirement, is now an engineering consultant for the Laboratories and devotes his efforts to part-time work on military communication problems at the Whippany, N. J., location.

Engineering Societies Honor J.W.Gewartowski And W. O. Fleckenstein

James W. Gewartowski of the Electron Tube Development Department has been named winner of the 1960 Browder J. Thompson Memorial Prize. This award is given annually to an author under 30 years of age who has written an I.R.E. paper combining the best technical contribution and presentation. His paper, "Velocity and Current Distributions in the Spent Beam of the Backward-Wave Oscillator," appeared in the October, 1958, issue of *I.R.E. Transactions on Electron Devices.*

This is the third consecutive year that a member of the Laboratories has won this prize. Franklin H. Blecher, Transmission Networks Development Engineer, won the prize last year. The 1958 award was won by Arthur Karp, who left the Laboratories to continue his studies in England.

William O. Fleckenstein, Data Systems Development Engineer, received honorable mention by Eta Kappa Nu as an "outstanding young electrical engineer." Eta Kappa Nu is the national electrical engineering honorary society.

A jury of engineering leaders chose one winner and three honorable mentions in this 24th annual selection. The men chosen will be honored at Eta Kappa Nu's awards dinner to be held February 1, 1960, in New York City.

Members of Laboratories Active in AIEE For the 1959-1960 Year

A number of Laboratories people are serving the American Institute of Electrical Engineers in official capacities for the year 1959-1960.

Board of Directors, E. I. Green. General committees: Professional Development and Recognition, R. A. Heising (retired), H. A. Affel (retired). Board of Examiners, R. A. Heising (retired), E. C. Molina (retired), F. J. Singer, J. D. Tebo. Edison Medal and Finance, E. I. Green; Prize Awards, W. Keister, J. Meszar. Publications, E. I. Green, J. D. Tebo; Safety, L. S. Inskip, and A. B. Haines, Division Liaison Representative; Standards, P. T. Sproul, L. S. Inskip; Periodicals and Transactions, W. H. MacWilliams, Jr.; Special Publications, P. B. Findley (retired); Planning and Coordination, E. I. Green; Professional Conduct, H. A. Affel (retired); Research, J. D. Tebo; Education, R. M. Bozorth, E. I. Green; Recognition Awards, J. Meszar; Technical Operations, J. Meszar, J. D. Tebo, D. E. Trucksess, W. H. MacWilliams, Jr.

Technical Committees: Communication Division Committee, E. I. Green, W. Y. Lang, H. F. May, J. Meszar, L. R. Montfort, L. S. Schwartz, L. G. Abraham (Vice Chairman), H. A. Affel (retired), D. T. Osgood; Broadcasting, H. J. Fisher; Communication Switching Systems, H. F. May (Chairman), C. A. Armstrong, A. E. Joel, W. Keister, R. S. Niekirk; Automation and Data Processing, W. T. Rea, W. Keister; Man-Machine Integration, W. H. MacWilliams, Jr. (Chairman); B. D. Holbrook (Secretary), W. Keister, E. K. Van Tassel. Communication Theory, L. G. Abraham, W. R. Bennett, W. A. Depp; Data Communication, R. M. Gryb, L. A. Weber, A. L. Whitman; Radio Communication Systems, P. T. Sproul (Vice Chairman and Liaison Representative on Standards Committee), W. W. Sturdy; Military Radio Communications Subcommittee, W. W. Sturdy (Chairman); Telegraph Systems, W. Y. Lang, R. B. Shanck (retired); Printing Telegraph Subcommittee, W. Y. Lang (Chairman); Wire Communication Systems, D. T. Osgood (Chairman), L. R. Montfort; Special Instruments and Auxiliary Apparatus, S. J. Zammataro; Ground Resistance Subcommittee, W. C. Ball; Fundamental Electrical Standards Subcommittee, S. J. Zammataro; Wire Line Protection Subcommittee, L. H. Sessler; Protective Devices, J. R. Hayes, Jr.; Fault Limiting Devices Subcommittee, J. R. Hayes, Jr.; Lightning Protective Devices Subcommittee, D. W. Bodle; Insulation Life Subcommittee, E. E. Aldrich (alternate), and L. W. Kirkwood, Working Group on Insulation Requirements for Specialty Transformers; Science and Electronics Division Committee, D. E. Trucksess (Chairman), A. B. Haines; Basic Sciences, R. M. Bozorth, V. E. Legg; Electric Circuit Theory Subcommittee, J. T. Bangert, R. McFee; Magnetics Subcommittee, R. A. Chegwidden (Secretary), R. M. Bozorth, V. E. Legg; New Concepts Subcommittee, V. E. Legg; Computing Devices, B. D. Holbrook; Prize Award Subcommittee, B. D. Holbrook (Chairman); Gaseous Insulation Subcommittee, T. B. Jones; Electronics, L. W. Kirkwood; Hot Cathode Converters Subcommittee, D. H. Smith, D. E. Trucksess; Electronics Transformers Subcommittee, L. W. Kirkwood (Chairman), A. D. Hasley.

Magnetic Amplifiers, A. B. Haines (Chairman), P. L. Schmidt (Secretary), E. J. Alexander, D. Katz, J. J. Suozzi; Applications Subcommittee, D. Katz (Chairman), E. J. Alexander (Secretary); Definitions Subcommittee, T. G. Blanchard, A. B. Haines; Materials Subcommittee, J. R. Conrath, P. L. Schmidt, F. F. Siebert; Planning Subcommittee, A. B. Haines, P. L. Schmidt

(Secretary), D. Katz; Theory Subcommittee, H. L. Goldstein, A. B. Haines; Combined Magnetic and Semiconductor Devices Subcommittee, E. J. Alexander, H. L. Goldstein, P. L. Schmidt; Semiconductor Metallic Rectifiers, J. Gramels (Secretary), D. E. Trucksess; Administrative Subcommittee, J. Gramels (Secretary), D. E. Trucksess; Service Subcommittee, Standards Group, J. Gramels; Solid State Devices Committee, Dielectric Device Subcommittee, J. H. Armstrong.

Intersociety Representatives—Engineering Foundation Board, J. D. Tebo; Engineers Joint Council Board of Directors, J. D. Tebo; John Fritz Medal Board of Award, E. C. Molina.

Western Electric Now Making Traveling Wave Tube For TH Radio Relay System

A traveling wave tube developed at Bell Laboratories is now coming off the production line at the Allentown plant of the Western Electric Company. Representing a major advance in microwave communications, the tube is arriving just as a rapid expansion of existing facilities for radio-relay transmission is taking place.

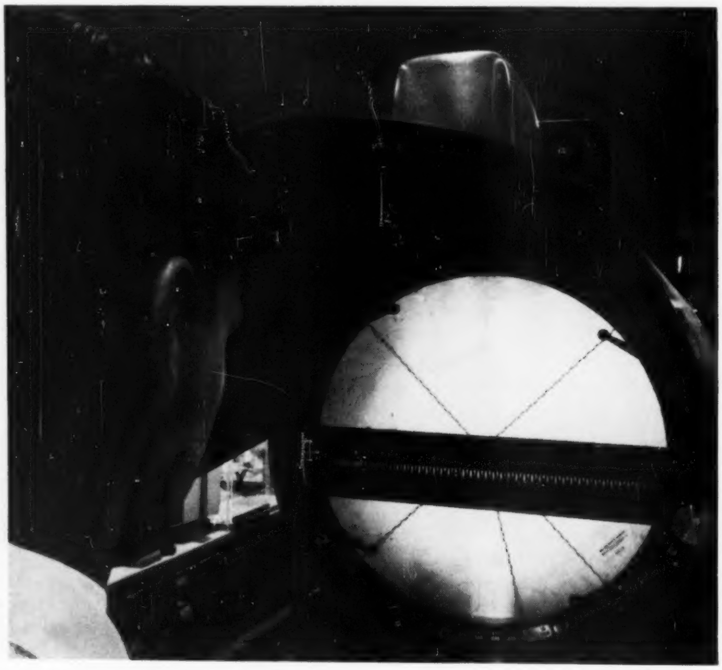
With this new tube, the six-channel TH Microwave Radio-Relay System, developed at the Laboratories, will be able to transmit more than 11,000 telephone calls simultaneously, or 12 TV programs and 2500 conversations. This compares to the present five-channel TD-2 system which can accommodate only 3000 messages. The TH system equipment will be integrated, wherever possible, for maximum transmission capacity with the present TD-2 System.

The basic parts of a traveling wave tube are an electron emitter or "gun"; a long, high-precision coil of wire, the "helix," which is the heart of the tube; and an electron "collector." All are sealed in a long-necked glass envelope.

At the base of the tube, the electron gun shoots a steady beam of electrons through the axis of the helix to the collector at the tube's far end. The radio signal to be amplified enters the tube at the base and follows the corkscrew path provided by the helix. As the electron beam and the radio signal travel through the tube, an interaction occurs that results in a transfer of energy from the beam to the signal.

This transfer might be compared to the action between wind — the electron beam — and ocean waves — the radio signal. As the wind blows over the ocean it imparts some of its strength to the waves, which grow larger and larger. In a similar manner, by passing through the traveling wave tube, a radio signal can be increased in strength as much as ten thousand times.

Manufacture of these tubes must meet the highest production standards to guarantee reliable operation. Western Electric production people make parts to tolerances as fine as one five-thousandths of an inch. The tubes are kept exceptionally clean by the use of dust-free assembly facilities and the wearing of nylon smocks by everyone working or visiting in the area.



Western Electric technician inspects helix of a traveling wave tube in an optical "comparator."

PAPERS

Following is a list of the authors, titles, and places of publication of recent papers published by members of the Laboratories.

Abbott, H. H., *A New Small Crossbar Telephone System for Private Branch Exchanges*, Trans. A.I.E.E. Communication and Electronics, 40, pp. 911-918, Jan., 1959.

Abel, J. L., and Chynoweth, A. G., *Built-In Nucleation Sites in Triglycine Sulfate*, J. Appl. Phys., 30, pp. 1615-1617, Oct., 1959.

Brout, R., *Statistical Mechanical Theory of a Random Ferromagnetic System*, Phys. Rev., 115, pp. 824-835, Aug. 15, 1959.

Chynoweth, A. G., see Abel, J. L.

Chynoweth, A. G., and McKay, K. G., *Light Emission and Noise Studies of Individual Microplasmas in Silicon Junctions*, J. Appl. Phys., 30, pp. 1811-1813, Nov., 1959.

Cook, J. S., and Louisell, W. H., *Traveling Wave Tube Equations Including the Effects of Parametric Pumping*, Proc. I.R.E,. 47, No. 11, p. 2016, Nov., 1959.

Curtis, H. E., *Probability Distribution of Noise Due to Fading on Multisection FM Microwave Systems*, Trans. I.R.E. on Communications Systems, Cs-7, No. 3, pp. 161-167, Sept., 1959.

Dorros, I., *How to Design a Sure-Starting Multi and Couple It to a Load*, Electronic Design, 7, No. 23, pp. 46-49, Nov. 11, 1959.

Fulda, S. M., and Sherry, M. E., *Calculation of Gamma Functions to High Accuracy*, Math. Tables and Other Aids to Computation, Chapter XIII, pp. 314-315, Oct., 1959.

Geller, S., *On the Relationship Between the β-W and Garnet Structures*, Acta Crys., 12, pp. 944-945, Nov. 10, 1959.

Geller, S., and Mitchell, D. W., *Rare Earth Ion Radii in the Iron Garnets*, Acta Crys., 12, p. 936, Nov. 10, 1959.

Gyorgy, E. M., and Humphrey, F. B., *Flux Reversal in Soft Ferromagnetics*, J. Appl. Phys., 30, pp. 935-939, June, 1959.

Hagedorn, F. B., *Uniform Rotational Flux Reversal of Ferrite Toriods*, J. Appl. Phys., 30, pp. 1368-1375, Sept., 1959.

Humphrey, F. B., see Gyorgy, E. M.

Humphrey, F. B., Reynolds, F. W., and Stilwell, G. R., *Introduction to Magnetic Thin Films*, 1958 Trans. of Vacuum Symposium, pp. 204-211, 1958.

Logan, R. A., and Peters, A. J. *Diffusion of Oxygen in Silicon*, J. Appl. Phys., 30, pp. 1627-1630, Nov., 1959.

Louisell, W. H., see Cook, J. S.

McKay, K. G., see Chynoweth, A. G.

Miller, R. C., and Savage, A., *Asymmetric Hysteresis Loops and the Pyroelectric Effect in Triglycine Sulfate*, J. Appl. Phys., 30, pp. 1646-1648, Nov., 1959.

Mitchell, D. W., see Geller, S.

Morley, A. R., *P.C. Peg Boards Speed Breadboard Layout*, Electronic Design, 7, pp. 94-95, Oct. 28, 1959.

Peters, A. J., see Logan, R. A.

Reynolds, F. W., see Humphrey, F. B.

Savage, A., see Miller, R. C.

Schroeder, M. R., *Measurement of Sound Diffusion in Reverberation Chambers*, J. Acous. Soc. Am., 31, pp. 1407-1414, Nov., 1959.

Sherry, M. E., see Fulda, S. M.

Slichter, W. P., *Nuclear Resonance Studies of Motion and Configuration in Glassy Polymers*, Annals N. Y. Acad. Sci., 83, pp. 60-75, Oct. 28, 1959.

Slichter, W. P., *Nuclear Resonance Studies of Polymer Chain Flexibility*, A.S.T.M. Spec. Tech. Publ., 247, pp. 257-269, Oct., 1959.

Stilwell, G. R., see Humphrey, F. B.

van Bergeijk, W. A., *Hydrostatic Balancing Mechanism of Xenopus Larvae*, J. Acous Soc. Am., 31, pp. 1340-1347, Oct., 1959.

Weiss, J. A., *A Phenomenological Theory of the Reggia-Spencer Phase Shifter*, Proc. I.R.E., 47, pp. 1130-1137, June, 1959.

PATENTS

Following is a list of the inventors, titles and patent numbers of patents recently issued to members of the Laboratories.

Anderson, J. R. — *Storage Matrix Access Circuits* — 2,914,748.

Ashenhurst, R. L. and Minnick, R. C. — *Electrical Circuits Employing Sensing Wires Threading Magnetic Core Memory Elements* — 2,912,677.

Bartram, J. F. and Evans, D. H. — *Beam Positioning Apparatus* — 2,913,622.

Becker, E. J., Cleveland, H. M., Pondy, P. R., and Robinson, H. J. — *Method of Making Sintered Cathodes* — 2,914,402.

Bonorden, A. R. — *Translator* — 2,912,679.

Bownik, N. J., Jr. — *Magnetic Pulse Generator* — 2,912,602.

Cleveland, H. M., see Becker, E. J.

Cutler, C. C. — *Corrugated Wave Guide Devices* — 2,912,695.

PATENTS (CONTINUED)

D'Altroy, F. A. and Pondy, P. R. — *Gas Seal* — 2,913,077.

Dagnall, C. H., Jr. and Miller, C. G. — *Disconnect Control of Telephone Answering and Message Recording Devices* — 2,912,504.

Davey, J. R. — *Diode Comparison Gate* — 2,912,582.

Davey, J. R. and Rea, W. T. — *Telegraph Start-Stop Synchronizer and Corrector* — 2,914,612.

De Lange, O. E. — *Microwave Pulse Circuits* — 2,912,581.

De Lange, O. E. — *Microwave Switching Circuits* — 2,914,671.

Early, J. M. — *Method of Fabricating Semiconductive Translating Devices* — 2,912,371.

Evans, D. H., see Bartram, J. F.

Fox, A. G. — *Nonreciprocal Circuit Element* — 2,913,678.

Fritschi, W. W. and Weaver, A. — *Magnetic Core Circuits* — 2,914,617.

Goodall, W. M. — *Microwave Data Processing Circuits* — 2,914,249.

Gustafson, W. G. and Harrison, H. G. — *Mercury Switches* — 2,911,500.

Harrison, H. C., see Gustafson, W. G.

Kaufman, A. W. and Votaw, C. J. — *Automatic Teletypewriter Station Control System* — 2,912,485.

Kock, W. E. — *Apparatus for Utilization of Higher Order Acoustic Waves* — 2,912,061.

Kompfner R. and Suhl, H. — *Non-Reciprocal Wave Transmission Device* — 2,911,554.

Kramer, H. P. and Mathews, M. V. — *Reduction of Redundancy and Bandwidth* — 2,911,476.

Kretzmer, E. R. — *High Resolution Scanning System* — 2,911,-463.

Mathews, M. V., see Kramer, H. P.

McKim, B. — *Translator Using Diodes and Transformers* — 2,912,511.

Miller, C. G., see Dagnall, C. H., Jr.

Minnick, R. C., see Ashenhurst, R. L.

Ostendorf, B., Jr. — *Shift Register Circuit Controlled by a Pulse Generating Circuit* — 2,911,544.

Pondy, P. R., see D'Altroy, F. A.

Pondy, P. R., see Becker, E. J.

Rea, W. T., see Davey, J. R.

Riggs, G. and Schunneman, R. F. — *Telephone Call Charge and Tax Calculator* — 2,911,150.

Robinson, H. J., see Becker, E. J.

Schunneman, R. F., see Riggs, G.

Straube, H. M. — *Lockout Circuits Utilizing Thermistor-Gas Tube Combinations* — 2,914,747.

Suhl, H., see Kompfer, R.

Tanenbaum, M. — *Photocell Array* — 2,911,539.

Unger, H. G. — *Waveguide Bend* — 2,914,741.

Uhlir, A., Jr. — *Semiconductor Diode* — 2,914,715.

Votaw, C. J., see Kaufman, A. W.

Weaver, A., see Fritschi, W. W.

Weinberg, S. B. and Williford, O. H. — *Telephone Alarm System* — 2,911,474.

Williford, O. H., see Weinberg, S. B.

Younker, E. L. — *Multivibrator Circuits* — 2,913,578.

TALKS

Following is a list of speakers, titles, and places of presentation for recent talks presented by members of Bell Laboratories.

AMERICAN VACUUM SOCIETY MEETING, Philadelphia, Pa.

Ahearn, A. J., *Mass Spectrographic Studies of Impurities on Surfaces.*

Moore, G. E., *The Ionization of Adsorbed Gas by Impact of Slow Electrons.*

Morrison, J., *The Behavior of Titanium in a High Vacuum.*

CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, Detroit, Michigan

Adley, R. E., see Legg, V. E.

Clogston, S. M., *Interaction of Magnetic Crystals with Radiation of 10^4 to 10^5 Cm^{-1}.*

Dillon, J. F., and Nielsen, J. W., *Ferrimagnetic Resonance in Impurity Doped Yttrium Iron Garnet.*

Geller, S., *Magnetic Interactions and Distribution of Ions in the Garnets.*

Heidenreich, R. D., Nesbitt, E. A., and Williams, A. J., *A Necessary Factor for Heat Treatment of the Permalloys in a Magnetic Field.*

Herring, C., *The State of d Electrons in Transition Metals.*

Legg, V. E., and Adley, R. E., *Effects of Hydrostatic Pressure on the Properties of Magnetic Materials.*

Long, T. R., *Electrodeposited Memory Elements for a Nondestructive Memory.*

Matthias, B. T., *Relations Between Superconductors and Ferromagnets.*

Nesbitt, E. A., see Heidenreich, R. D.

Nielsen, J. W., see Dillon, J. F.

Williams, A. J., see Heidenreich, R. D.

ELECTROCHEMICAL SOCIETY MEETING, Columbus, Ohio

Allen, F. G., Buck, T. M., and Law, J. T., *P-Layers on Vacuum Heated Silicon.*

Buck, T. M., *Damaged Surface Layers — Semiconductors.*

Buck, T. M., see Allen, F. G.

Ditzenberger, J. A., Struthers, J. D., and Whelan, J. M., *Purification of Arsenic.*

Law, J. T., see Allen, F. G.

Lawrence, H., and Warner, R. M., Jr., *Depletion Layer Calculations for the Design of Diffused Semiconductor Devices.*

Struthers, J. D., see Ditzenberger, J. A.

Turner, D. R., *Electrolytic Etching of Semiconductors.*

Warner, R. M., Jr., see Lawrence, H.

Whelan, J. M., see Ditzenberger, J. A.

58TH MEETING OF ACOUSTICAL SOCIETY OF AMERICA, Cleveland, Ohio.

David, E. E., Jr., Mathews, M. V., and Miller, J. E., *Pitch Synchronous Spectral Analysis of Vowel Sounds.*

David, E. E., Jr., and Schodder, G. R., *Pitch Discrimination of Complex Sounds.*

David, E. E. Jr., *Review of Current European Research in Speech and Auditory Perception.*

Fisher, E. S., see McSkimin, H. J.

Frishkopf, L. S., and Guttman, N., *Effect of Prior Monaural Click on Time Between Critically Fused Binaural Clicks.*

Guttman, N., see Frishkopf, L. S.

Hanson, R. L., *Clues to Sound Localization.*

Harris, G. G., *On the Binaural Interaction of Impulsive Stimuli and Pure Tones.*

Mathews, M. V., see David, E. E., Jr.

McDonald, H. S., *A Note on Low Pass Filters for Retrieving Sampled Speech Signals.*

McSkimin, H. J., and Fisher, E. S., *Measurement of the Adiabatic Elastic Moduli of Alpha Uranium as a Function of Temperature.*

Miller, J. E., see David E. E., Jr.

Schodder, G. R., see David E. E., Jr.

Schroeder, M. R., *New Results Concerning Monaural Phase Sensitivity.*

OTHER TALKS

Abbott, H. H. *A New Small Crossbar Telephone System for Private Branch Exchanges,* A.I.E.E. Fall General Meeting, Chicago, Ill.

Anderson, O. L., *The Adhesion of Metals at Room Temperature,* University of California, Berkeley, Calif.

Atalla, M. M., and Tannenbaum, M., *Impurity Redistribution and Junction Formation in Silicon by Thermal Oxidation,* Electrochemical Society Fall Meeting, Washington, D. C.

Bailey, C. M., Jr., *Design of a Saturable Core Power Inverter,* National Electronics Conferences, Chicago, Ill.

Baker, W. O., see Hopkins, I. L.

Blackman, R. B., *The Practical Aspects of Linear, Least Squares Filters,* Electrical Engineering Department Graduate Seminar, Columbia University, N. Y. C.

Bobeck, A. H., *Recent Advances in Twistor Memories,* I.R.E. Prof. Gp. on Electron Devices, N. Y. C.

Burton, J. A., *Photoelectric Emission from Cs_3Db and Electron Emission from Avalanche Breakdown in Si.,* Department of Physics, Purdue University, Lafayette, Ind.

Cutler, C. C., *Communications in Space,* Worcester Polytechnic Institute Alumni Association, Ridgefield, N. J.

Darlington, S., *The Theory of Linear, Least-Squares Filters,* Electrical Engineering Department Seminar, Columbia University, N. Y. C.

Davis, R. E., *Microwave Germanium Transistor,* University of Western Ontario, London Ontario, Canada.

DeGrasse, R. W., *Ultra-Low-Noise Antenna and Receiver Combination for Satellite or Space Communication,* National Electronics Conference, Chicago, Ill.

DeGrasse, R. W., and Scovil, H. E. D., *Precise Measurement of Traveling Wave Maser Noise — Intrinsic, Preamplifier, and Receiving System,* Seventeenth Annual Conference on Electron Tube Research, Mexico City, Mexico.

Engelbrecht, R. S., and Mumford, W. W., *Parametric Amplifiers: Historical Background and Recent Results with UHF Traveling Wave Amplifiers Using Diodes,* Monmouth Subsection I.R.E., Little Silver, N. J.

Frosch, C. J., and Gershenzon, M., *The Preparation and Properties of Gallium Phosphide,* Symposium on Preparation of Single Crystals of the III-V Compounds, Battelle Memorial Institute, Columbus, Ohio.

Galt, J. K., *Cyclotron Resonance in Metals,* A.S.M., Chicago, Ill.

Geller, S., *Magnetic Interactions and Distribution of Ions in the Garnets,* Solid-State Chemistry Seminar, Columbia University, N. Y. C.

Gershenzon, M., see Frosch, C. J.

Graney, E. T., and Kern, H. E., *High Purity Cathode Nickel Alloys for Oxide Cathode Studies,* A.S.T.M. Meeting of F-1 Committee, Skytop, Pa.

Greiner, E. S., *Preparation and Electrical Resistivity of Boron and Some Boron-Phosphorus Alloys,* A.I.M.E. Metallurgical Society, Chicago, Ill.

Gresh, M., Schwartz, N., and Werner, J. K., *Properties of Aluminum Solid Electrolytic Capacitors,* Conference on Electrical Insulation, Pocono Manor, Pa.

Hamming, R. W., *Where is the Computer Field Heading?* A.C.M. Kingston Chapter, Rhinebeck, N. Y.

Harris, G. G., *Psychoacoustic Scales,* A.I.E.E.-I.R.E. Audio Technical Group, Cleveland Engineering Society, Cleveland, Ohio.

Hasley, A. D., *Progress Report on the A.I.E.E. Tentative Proposed Standard for Low Power Wide-Band Transformers,* Control Systems Components Conference, Dallas, Texas.

Healy, M. J. R., *The Analysis of Variance,* A.C.S./A.S.Q.C., North Reading, Mass.

Heidenreich, R. D., and Reynolds, F. W., *Uniaxial Magnetic Anisotropy and Microstructure of Ferromagnetic Metal Films,*

International Conference on Thin Films, Lake George, N. Y.

Hershey, J. H., *The Reliability Concept*, Northern New Jersey Section I.R.E., Fall Lecture Series on Components and Reliability, Montclair, N. J.

Higgins, W. H. C., *Command Guidance for Ballistic Missiles and Space Vehicles*, Armed Forces Communications Electronics Association Meeting, N. Y. C.

Hopkins, I. L., and Baker, W. O., *Stress Cracking of Polyethylene*, International Union of Pure and Applied Chemistry, Dusseldorf, Germany.

Jaycox, E. K., *Sampling for Spectrochemical Analysis*, Eastern Analytical Symposium, N. Y. C.

Kabak, I. W., *Determining Optimum Manufacturing Dimensions*, Student Chapter A.I.I.E., New York University, N. Y. C.

Kern, H. E., see Graney, E. T.

Kinariwala, B. K., *Introduction to Active Circuits*, I.R.E. Lecture Series, University of Pennsylvania, Philadelphia, Pa.

Kunzler, J. E., *Some Recent Advances in Metallurgical Research at Low Temperatures*, New York Section of the A.I.M.E., Physical Metallurgy Group, Perth Amboy, N. J.

Leamer, F. D., *Aids to the Teaching of Science and Engineering*, Physics and Engineering Faculty, State University of Iowa, Iowa City, Iowa.

Leenov, D., Rood, J., *Large Power Harmonic Generation with a Silicon Varactor Diode*, I.R.E. Prof. Gp. on Electron Devices, Washington, D. C.

Logan, B. F., *The Complex Zeros of Bandlimited Gaussian Noise*, U.R.S.I./I.R.E., San Diego, Calif.

Loomis, T. C., *X-Ray Spectrochemical Analysis*, A.C.S. Meeting, Wilmington, Del.

Looney, D. H., *Magnetic Memory Devices*, A.I.E.E. Student Seminar, Purdue University, Lafayette, Ind.

Mathews, M. W., *The Effective Use of Digital Simulation for Speech Processing*, Air Force Cambridge Research Center, Bedford, Mass.

Mendizza, A., *Plating of Electrical Contacts*, Burndy Corporation Engineers Club, Norwalk, Conn.

Morgan, S. O., *The Contribution of Chemists to Insulation*, John B. Whitehead Memorial Lecture, Conference on Electrical Insulation, Pocono Manor, Pa.

Morgan, S. P., *Applied Mathematical Research*, Fall Convention of the Association of Teachers of New Jersey, Atlantic City, N. J.

Mumford, W. W., *Technical Aspects of Microwave Radiation Hazards*, A.T.&T. Company Regional Conferences: Denver, Colo., August 11; New York City, September 15; Chicago, Ill., October 6.

Mumford, W. W., see Engelbrecht, R. S.

Nelson, L. S., *Flash Induction of Thermal Reactions*, A.C.S., Meeting of Physical Chemical Group, Pittsburgh, Pa.

Olsen, K. M., *Effect of Trace Elements on the Tensile, Electrical Resistance and Recrystallization Properties of High Purity Nickel*, A.S.M. Meeting, Chicago, Ill.

Pfann, W. G., *Controlled Freezing as a Metallurgical Technique* Hudson-Mohawk Section A.I.M.E., Schenectady, N. Y.

Reed, E. D., *A Review of Variable-Capacitance Parametric Amplifiers*, Convention of Nachrichtentechnesche Gesellschaft, Stuttgart, Germany.

Reynolds, F. W., see Heidenreich, R. D.

Rider, D. K., *Temperature Rise in Structures Due to Solar Heating*, Third Pacific Area National A.S.T.M. Meeting, San Francisco, Calif.

Rood, J., see Leenov, D.

Ross, I. M., *Functional Devices*, I.R.E. Prof. Gp. on Electron Devices, Washington, D. C.

Schlabach, T. D., *Molded Circuitry Materials and Processes*, Symposium on Printed Circuits, Bell Telephone Laboratories, Murray Hill, N. J.

Schulz-DuBois, E. O., *The Present Status of Solid-State Maser Development*, Conference of Seutsche Forschungsgemeinschaft Hirschegg, Kleines Walsertal, Austria.

Schwartz, N., see Gresh, M.

Schwenker, J. E., *Time Sharing and Pulse Coding*, Area Power Conference, Fargo, N. D.

Scovil, H. E. D., *Solid-State Masers*, Solid State and Plasma Physics Symposium, Johns Hopkins University, Baltimore, Md.

Scovil, H. E. D., see DeGrasse, R. W.

Sipress, J. M., *Active RC Filters*, I.R.E. Prof. Gp. on Circuit Theory, Syracuse, N. Y.

Slichter, W. P., *Nuclear Resonance Studies of Motion in Polymers*, Northwestern University, Evanston, Ill.

Slichter, W. P., *Nuclear Resonance Studies of Motion in Polymers*, Symposium on Micromolecules, Wiesbaden, Germany.

Stadler, H. L., *Ferroelectric Switching of $BaTiO_3$*, Physics Department, Colloquium, Rensselaer Polytechnic Institute, Troy, N. Y.

Stadler, H. L., *Magnet Cards for the Permanent Magnet Memory*, Symposium on Printed Circuits, Bell Telephone Laboratories, Murray Hill, N. J.

Tannenbaum, M., see Atalla, M. M.

Thomas, D. G., *Excitons in Zinc Oxide and Cadmium Sulphide*, University of Illinois, Urbana, Ill.

Troe, J. L., *The Nike-Hercules Guided Missile System*, Mt. Tabor Methodist Church Men's Club, Mt. Tabor, N. J.

Walker, L. R., *The Ferromagnetic Amplifier*, Johns Hopkins University Radiation Laboratory, Baltimore, Md.

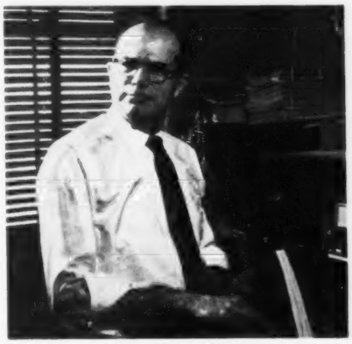
Werner, J. K., see Gresh, M.

THE AUTHORS

R. E. Hersey

R. E. Hersey's first telephone experience consisted of an improvised "tomato can" receiver and "carbon button" transmitter for his pioneer father's "farmer line" telephone. This was at age 12 in the South Dakota farmhouse in which he was born. Mr. Hersey joined the Western Electric Engineering Department in 1922 with a B.S. (1918) degree in Physics and Mathematics from Beloit College, and additional graduate studies at the Sorbonne and Harvard. His education was interrupted by two years in the Signal Corps during World War I, where he served in the St. Mihiel and Meuse-Argonne sectors in France with the 307th Field Signal Battalion. At the Laboratories, he has been concerned with circuit development on various dial systems, including panel, No. 1 crossbar, No. 4 toll, No. 5 crossbar, the first application of keysets on DSA and toll switchboards, and the first application of Direct Distance Dialing. At present, he is Engineering Consultant in the Switching Engineering Department, concerned with ESS. Mr. Hersey is the author of "Machine Memory In Telephone Switching" in this issue.

C. A. Collins ("Closed-Circuit Educational TV Systems") was born in England and received the B.S. degree from the University of Washington in 1925. After five years with the Pacific Telephone Company, he joined the Switching Systems Development Department at Bell Laboratories where until 1942 he was engaged in the development of step-by-step and crossbar switching systems. During the war years he was an instructor in the Bell Laboratories School for War Training. From 1945 to 1954 he participated in engineering studies of proposed new switching systems including No. 5 crossbar, subscriber line concentrators and electronic switching. In 1954 he transferred to Transmission Engineering where he has since been concerned with engineering requirements for video switching equipment and closed circuit TV systems.



C. A. Collins

W. E. Ingerson, a native of Barstow, Texas, received his B.S. degree from Hardin - Simmons University in 1933, and his M.S. in Electrical Engineering from Yale University in 1937. He joined the Laboratories in August, 1937, working initially in the Material Standards Department. Shortly after Pearl Harbor, Mr. Ingerson transferred to a group developing anti-aircraft director systems. His work since that time has continued to be in the field of director systems for guns and guided missiles. Early in 1951 he was placed in charge of a group responsible for the electrical design of the Nike Ajax Computer. In September, 1953 he transferred to White Sands, New Mexico, where he helped establish

W. E. Ingerson

the White Sands Laboratory for the field evaluation of Nike systems. In March, 1959, he was named Missile Systems Test Engineer at White Sands. Mr. Ingerson is a member of Sigma Xi, received honorable mention in the Eta Kappa Nu Recognition of Outstanding Young Electrical Engineers for 1943, and holds several patents in the fields of crystal technology and analog computers. He is the author of "The Nike Ajax Computer" in this issue.

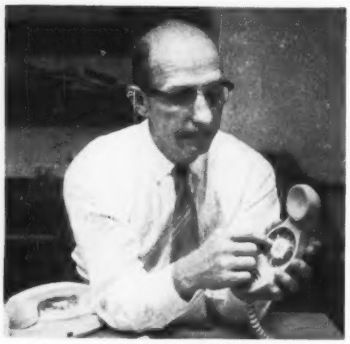
John K. Werner was born in Rajahmundry, India. He received the B.S. degree from Trinity College, Hartford, Connecticut, in 1939, and the Ph.D. degree from Michigan State College in 1953. He joined Bell Laboratories in 1952, concerned initially with dielectric strength studies on insulating oil. He also engaged in development of carbon potentiom-

J. K. Werner

eters and special resistors. He participated in development of lacquer-film capacitors and improved electrolytic capacitors, the subject of his article in this issue. Mr. Werner, a member of the American Chemical Society, the A.A.A.S. and Sigma Xi, left the Laboratories recently.

H. G. Wehe

Herman G. Wehe, born in Topeka, Kansas, received the A.B. degree from Washburn College, Topeka, Kansas, in 1922, and the M.A. degree in 1925 from the University of Kansas. He began telephone work with an independent company in 1925, and joined the Bell System the following year with the Western Electric Company. He came to Bell Laboratories in 1929 where he has worked on magnetics, microgas analysis, pyrolytic carbon deposition, and vacuum vapor plating. Mr. Wehe originated the process for vacuum vapor plating organic crystals for piezoelectricity for submarine detection. He also developed techniques and equipment for producing and using vapor-plated thin films, particularly on resistor, capacitor, and optical components. His discoveries include a new method for converting light to mechanical motion or to ac electricity, and for high-speed electron-beam recording of television pictures on transparent plastics. Mr. Wehe co-authored the article on "A Miniature Lacquer-Film Capacitor."



W. E. Whidden

W. E. Whidden, a native New Yorker, joined the Laboratories as a technical assistant in 1925 and became a member of the technical staff in 1929. He received his E.E. degree from the Polytechnic Institute of Brooklyn, and is a member of Eta Kappa Nu. Throughout most of his Bell System career, he has been engaged in the development of devices for the production of audible sounds or signals, beginning with the early electro-mechanical recording and reproduction of speech and music. During the war years, he was concerned with the development of low-frequency, under-water sound projectors. Since 1945, as a member of the Station Apparatus Development Department, he has been involved in the design of telephone ringers, auxiliary signals, and other new station facilities. In this issue he is the author of "An Experimental 'Dial-In-Handset' Telephone."

D. C. Koehler graduated from the University of Illinois in his home town of Urbana, receiving the degree of B.S. in General Engineering in 1941. Coming directly to the Laboratories, he participated in the mechanical design of the M-9 gun data computer, various bombsight and anti-aircraft radar equipment, the M-13 depth charge mechanism, and the UB and wire-spring relays. He received his M.S. degree in E.E. from Stevens Tech in 1950 and since 1954 he has supervised the mechanical design of the switching network and flying-spot and barrier-grid stores for ESS. His article in this issue is on this phase of the flying-spot store. He is a member of Tau Beta Pi, Phi Kappa Phi and the Society of Photographic Scientists and Engineers.

D. C. Koehler

J. J. Madden, a native New Yorker, joined the Laboratories in 1936. While in the Research Drafting Department, he participated in the design of the first Electrical Gun Director. During World War II, he was with the Army Ordnance Department. Upon his return to the Laboratories in 1946, he joined the Switching Research Department and engaged in the mechanical design of ECASS and DIAD, the early electronic switching systems. After assisting in the production testing of wire spring relays and the production design of several new mercury relays, he joined the ESS group in 1954, where he is currently designing flying-spot stores. Mr. Madden is a graduate of the Polytechnic Institute of Brooklyn with the M.E. degree and is co-author of "Mechanical Design of a Flying-Spot Store."

J. J. Madden

SHIP WITHOUT AN OCEAN

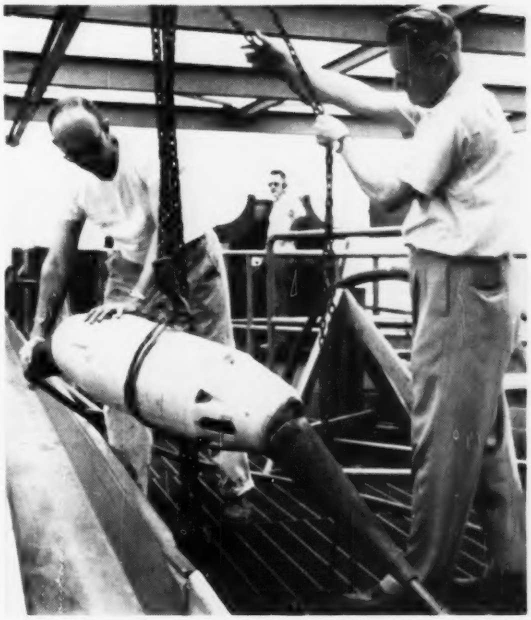
How do you lay a cable on the ocean floor—a cable that is connected to scores of large, heavy amplifiers? How do you "overboard" such a system in a continuous operation, without once halting the cable ship?

Bell Telephone Laboratories engineers must answer these questions in order to lay a new deep-sea telephone system designed to carry many more simultaneous conversations. They're experimenting on dry land because it is easier and more economical than on a ship. Ideas that couldn't even be attempted at sea are safely tested and evaluated.

In one experiment, they use a mock-up of the storage tank area of a cable ship (above). Here, they learn how amplifiers (see photo right), too rigid and heavy to be stored with the cable coils *below* decks, must be positioned *on* deck for trouble-free handling and overboarding.

Elsewhere in the Laboratories, engineers learn how best to grip the cable and control its speed, what happens as the cable with its amplifiers falls through the sea, and how fast it must be payed out to snugly fit the ocean floor. Oceanographic studies reveal the hills and valleys which will be encountered. Studies with naval architects show how the findings can be best put to work in actual cable ships.

This work is typical of the research and development effort that goes on at Bell Laboratories to bring you more and better communications services.



Experimental amplifier about to be "launched" from "cable ship." Like a giant string of beads, amplifiers and connecting cable must be overboarded without stopping the ship.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT